

N74-21161

PRODUCTION DEVELOPMENT OF ORGANIC
NONFLAMMABLE SPACECRAFT POTTING,
ENCAPSULATING AND CONFORMAL COATING COMPOUNDS

CONTRACT NAS 9-11068

VOLUME III

APPENDICES

(31 Jan 1974)

Sheldon L. Lieberman

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

Furane Plastics, Inc.
5121 San Fernando Rd. W.
Los Angeles, CA 90039

N O T I C E

THIS DOCUMENT HAS BEEN REPRODUCED FROM THE
BEST COPY FURNISHED US BY THE SPONSORING
AGENCY. ALTHOUGH IT IS RECOGNIZED THAT CER-
TAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RE-
LEASED IN THE INTEREST OF MAKING AVAILABLE
AS MUCH INFORMATION AS POSSIBLE.

111-1. a

LIST OF APPENDICES

<u>Appendices</u>	<u>Page</u>
A NAS 9-11068 Statement of Work: Production Development of Organic Nonflammable Spacecraft Potting, Encapsulating and Conformal Coating Compounds.	A-1 - A-12
B Material Vendor Contacts.	B-1 - B-14
C Formulation/Processing Data Sheet.	C-1 - C-3
D Upward Propagation Test.	D-1 - D-7
E NASA/Furane Flammability Test Facility.	E-1 - E-25
F Electrical Potting and Coatings Upward Propagation Flammability Test; Laboratory Checkout and Operational Procedure for: 3.0 psia Oxygen/7.0 psia Nitrogen.	F-1 - F-8
G Flammability Test Conditions/Results Data Sheet.	G-1 - G-3
H Determination of Offgassing Products and Carbon Monoxide Test.	H-1 - H-7
I Odor Test	I-1 - I-8
J SP-R-0022, "Specification: Vacuum Stability Requirements of Polymeric Material for Spacecraft Application."	J-1 - J-17
K GOX Pneumatic and Mechanical Impact Test Guidelines.	K-1 - K-22

APPENDIX

- A -

NAS 9-11068

STATEMENT OF WORK

PRODUCTION DEVELOPMENT OF NONFLAMMABLE
SPACECRAFT POTTING, ENCAPSULATING AND
CONFORMAL COATING COMPOUNDS

(Revised: 5 May 1972)

TABLE OF CONTENTS

	<u>Page No.</u>
1.0 Introduction	3
2.0 Objectives	3
3.0 Technical Requirements	4
3.1 Approach	4
3.2 Materials	4
3.2.1 Basic Compounds	4
3.2.2 Primers	4
3.2.3 Toxicity	4
3.3 Performance and Product Characteristics	5
3.3.1 Appearance	5
3.3.2 Application	5
3.3.3 Application Life	5
3.3.4 Curing Time	5
3.3.5 Storage Life	5
3.3.6 Repair and Rework	5
3.3.7 Temperature Rating	5
3.4 Properties and Test Requirements	5
3.4.1 Flammability	5
3.4.2 Offgassing	6
3.4.3 Odor	6
3.4.4 Vacuum Volatility	6
3.4.5 Physical and Electrical Properties	6
3.4.5.1 Potting & Encapsulating Compounds	6
3.4.5.2 Conformal Coatings	7
3.4.5.3 Patch Potting Adherence	7
3.4.5.4 Aging	7
3.4.6 Oxygen Impact	7
3.4.7 Special Testing Facilities	7
4.0 Production Procedure	8
5.0 Reports and Documentation	8
5.1 Progress Reports	8
5.2 Final Report	8
5.3 Cost Proposal for Additional Quantities	9

Appendix A - NHB 8060.1, "Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments That Support Combustion," Nov. 1971 Edition.

Appendix B - MSFC-SPEC 202A, "Compound, Potting and Molding, Elastomeric," dated December 11, 1964.

Appendix C - MSFC-SPEC-393A, Amendment 1, "Compound, Printed Circuit Board, Conformal Coating, Elastomeric," dated January 17, 1966.

1.0 Introduction

The polymeric potting, encapsulating and conformal coating compounds as used on the present generation of spacecraft, including the Apollo, while suited to conventional applications in ambient air constitute a fire hazard in pressures of oxygen as low as 6.2 psia unless encapsulated with relatively thick layers of inorganic coatings which may be brittle, tend to flake and crack, add substantial weight and hamper any wiring rework required.

The safety of any contemplated spacecraft or spacecraft in production can be improved by the use of nonflammable encapsulating materials. While it is obvious that the reduction of the fire hazard and toxicity of a spacecraft cabin is important, other advantages obtained from such a material should be emphasized. Weight reduction will be obtained with such a material as the weight of the inorganic coatings can be eliminated. Further, the added cost of applying these materials in the construction of a spacecraft can be avoided. The overall advantage of the use of a nonflammable encapsulant is increased safety, reduced weight and reduced manufacturing costs.

Large quantities of potting compounds are used to contain electrical components at connections and at terminations of the wiring. To be explicit, 311 places are so encapsulated on a typical Apollo-type spacecraft. This represents 79 pounds of encapsulant. About 25 pounds of Ladicote or some similar coating must protect this type of encapsulant. This extra coating must be applied in 142 uses. It is self-evident that the elimination of this extra overcoat would reduce fabrication, labor and material cost. Considerable progress has been made in the development of nonflammable potting, encapsulating and conformal coating compounds through previous contractual efforts.

Compounds are believed available, or are in advanced development stage, which can replace the current spacecraft materials. This proposed work effort, then, is directed toward the evaluation of potting compounds with a low degree of flammability and low toxicity characteristics with the realization that these compounds must possess the usual stringent electrical and physical properties and should be easily repaired and reworked if necessary.

Presently available compounds from previous contractual efforts or NASA in-house efforts must be tested, evaluated and, if required, modified to achieve the desired objective.

2.0 Objectives

It is required that materials developed by previous contractual effort and selected by the NASA-MSD technical monitor as starting material be subjected

to more intensive investigation with emphasis on raw material availability, selection and uniformity reproducibility, properties, limitations of fabrication conditions and the conformity of a production-type material to the complete requirements for the intended usage.

3.0 Technical Requirements

The material offered as a final product shall meet the criteria of this Section 3.0, and Tables I, II and III. In some cases, where required, criteria of the tables have been described in more detail by paragraphs 3.2 through 3.4.

3.1 Approach

The requirements detailed in Tables I through III have been attempted by several contractors. Copies of reports of these efforts will be supplied by NASA-MSC. Formulations evolved by these efforts and NASA in-house efforts should be investigated and evaluated relative to the availability, properties and cost of pertinent monomers, polymers, curatives, and additives. Fabrication methods shall be developed which will result in procedures capable of the production of a material meeting the work statement requirements. This procedure will be capable of production capacity required to produce material up to 1000 pounds per year of quality sufficient to meet the requirements of this work statement. Cost shall be a factor in this effort and every effort should be made to make the cost of this material comparable to current aerospace potting and encapsulants.

3.2 Materials

3.2.1 Basic Compounds - Any material inherently possessing adequate electrical and physical properties may be considered. However, the compounds developed by previous NASA contracts in this field must be considered and the use of other materials must be justified to the satisfaction of the NASA-MSC contract monitor. A maximum of 10 compounds shall be considered.

3.2.2 Primers - The use of a primer for potting, encapsulating, and/or conformal coatings, to improve the adhesion to the base structure is permitted, provided the composite primer and basic compound successfully pass all tests of paragraph 3.0

3.2.3 Toxicity - Any potentially toxic material such as listed in paragraph 7.C(1) (b), Test No. 7, Appendix A, associated with the processing or handling of the compounds shall be identified, and appropriate safety precautions shall be recommended.

3.3 Performance and Product Characteristics

- 3.3.1 Appearance - The as-poured and cured compounds shall be homogeneous and free from lumps and coarse particles and voids.
- 3.3.2 Application - Potting and encapsulating compounds shall be capable of being readily applied by an injection or extrusion gun. Conformal coatings shall be capable of being applied by brush, spray, or dipping.
- 3.3.3 Application Life - It is desired that the compound shall be suitable for application for a minimum of 60 minutes, but a minimum of 30 minutes is required.
- 3.3.4 Curing Time - The tack life of the compound should not exceed 6 hours at room temperature, but a maximum of 12 hours is required. The curing time to obtain optimum properties shall not exceed 7 days at room temperature and 50 percent maximum humidity. Elevated temperatures up to 150°F. may be used to accelerate the cure time. A vacuum post cure, not to exceed 8 hours at a maximum of 150°F, may be utilized when necessary to meet the requirements for the compound.
- 3.3.5 Storage Life - The uncured compounds shall be capable of meeting the requirements of this statement of work for 6 months when stored below 70°F.
- 3.3.6 Repair and Rework - The cured compounds must be capable of being removed, either mechanically or chemically, without damaging wiring, solder joints, or electronic components. The adherence of patch potting to previously applied potting must be adequate to withstand the 200 megohm moisture resistance tests of paragraph 3.4.5.3.
- 3.3.7 Temperature Rating - The compounds shall retain useful electrical properties at 212°F, as verified by the applicable insulation resistance tests of paragraph 3.4.5.

3.4 Properties and Test Requirements

- 3.4.1 Flammability - Candidate compounds shall be self-extinguishing, with no further evidence of degradation by combustion in 10.0 psia 30 percent oxygen/70 percent nitrogen when subjected to Test No. 1, NHB 8060.1 (Appendix A).

The Flammability Test Facility described in the Final Report of Contract NAS 9-8750 may be used for this test; specimen size to be adjusted accordingly. The final or ultimate sample(s) shall be subjected to the regular flammability test, as specified in the above paragraph, and shall be tested in triplicate at the NASA White Sands Testing Facility.

3.4.2 Offgassing - As a screening test, the total organics expressed as pentane equivalents evolved from any of the candidate potting, coating, or encapsulating materials shall not exceed 100 micrograms per gram of sample, when tested at 10 psia, 30% oxygen/70% nitrogen in accordance with Test No. 7, Appendix A. Offgassed carbon monoxide shall not exceed 25 micrograms per gram when tested in accordance with the same test. Identification of major peaks are required prior to final MSC acceptance of candidate materials. MSC acceptance shall be predicated upon the requirement that none of the offgassed products shall constitute a toxic hazard to the crew, based upon the criteria of Acceptability of Test No. 7, Appendix A.

3.4.3 Odor - The average odor rating of candidate materials must not exceed 2.0, when tested at 10 psia, 30% oxygen/70% nitrogen in accordance with Test No. 6, Appendix A.

3.4.4 Vacuum Volatility - The material shall meet the requirements of SP-R-0022 as a target requirement. Temperature requirements (SP-R-0022, Appendix 1, paragraph 2): The temperature of the specimen shall be 150°F.

An additional vacuum volatility test specimen shall be prepared per MSFC-SPEC-202A, paragraph 4.4.3.11 (See Appendix B) for potting compounds, and per MSFC-SPEC-393A, paragraph 4.5.2.10 (See Appendix C) for conformal coatings. Upon completion of 24-hour vacuum testing, there shall be no apparent visual degradation, and the compounds shall withstand the required 200 megohm moisture resistance tests of paragraph 3.4.7, Appendix B, for potting compounds, and paragraph 3.4.6, Appendix C, for conformal coatings.

3.4.5 Physical and Electrical Properties

3.4.5.1 Candidate potting and encapsulating compounds shall be tested in accordance with Appendix B, and meet the requirements of Table II.

- 3.4.5.2 Candidate conformal coatings shall be tested in accordance with Appendix C, and meet the requirements of Table II.
- 3.4.5.3 Patch Potting Adherence - The adherence of patch potting or coating material to previously applied compounds must be adequate to withstand the 200 megohm moisture resistance tests of paragraph 3.4.7, Appendix B, for potting compounds, and paragraph 3.4.6, Appendix C, for conformal coatings. The test samples shall be prepared with the required electrodes encapsulated by the applicable candidate compound. The upper portion of the cured compound shall be removed to a depth of at least one inch (1.00"), exposing both electrodes, to demonstrate compliance with paragraph 3.3.6. Patch potting or coating shall then be applied to replace the original compound, in accordance with the recommended process. The moisture resistance test shall be conducted on the "repaired" specimen to demonstrate dielectric integrity of the repair.
- 3.4.5.4 Aging - Aging tests will be devised and run on the final candidate material to insure, insofar as the state of the art permits, that the material will be serviceable as a potting, sealing, or conformal coating material for 10 years. As a target test requirement, the material will not lose more than 20% of its properties when subjected to ASTM Test D572-67, entitled "Standard Method of Test for Accelerated Aging of Vulcanized Rubber by the Oxygen-Pressure Method." Parameters for D572-67 shall be 96 hours at 159°F and 300 psia oxygen. Alternate aging tests may be used to demonstrate the age-life prediction if these methods can be demonstrated as effective to the satisfaction of the technical monitor.
- 3.4.6 Oxygen Impact - The cured material shall be tested for Oxygen Impact properties in accordance with the procedures of MSC-PA-D-67-13, Addendum 2A (7 June 1971), Test No. 10. The resultant data shall be included in the Final Report.
- 3.4.7 Special Testing Facilities - The NASA-MSC White Sands Test Facility is authorized to conduct the following tests for the

Contractor on a time availability basis in accordance with the applicable sections of the Statement of Work: Offgassing, Odor, Vacuum Volatility, and Oxygen Impact. Aging will be performed, if the Contractor does not have the necessary equipment, at a NASA facility of the NASA Technical Monitor's choice. The aging will be performed on a time availability basis. The Contractor shall promptly provide all necessary samples to the cognizant White Sands or MSC NASA Engineer, as appropriate, when the NASA Engineer advises the Contractor that time is available for testing. NASA will promptly submit all data, including photographic data when required by the NASA Technical Monitor, to Furane (Attention: S. L. Lieberman - Program Manager, NAS 9-11068), with one (1) copy to NASA-MSC (Attention: H. F. Kline/ES 5).

4.0 Production Procedure

Upon completion of testing, the optimum compound will be selected by the NASA Technical Monitor based upon results of the Contractor's testing program. The Contractor shall then proceed with development of the procedures necessary for production of 50 to 100 pound lots of the selected compound. The production procedure must be capable of producing up to 1,000 pounds of the compound per year of a quality consistent with the requirements of this Statement of Work. The Contractor shall document, as a part of the Final Report, the specific production procedures, processes, equipment requirements, etc., necessary for production of lot quantities of the compound. Fifty (50) pounds of the selected compound shall be delivered to NASA-MSC seven and one-half (7-1/2) months after receipt of a signed copy of the contract.

5.0 Reports and Documentation

5.1 Progress Reports

The Contractor shall submit monthly progress reports of all work accomplished during each month of contract performance. Monthly reports shall include data on compounds, test results, formulations, changes in processes, etc., necessary to explain overall progress during the reporting period.

5.2 Final Report

The Contractor shall submit a complete and detailed final report within seven and one-half (7-1/2) months after receipt of a signed

copy of the contract. This report shall include as a minimum the following information: An executive summary shall be supplied bound similarly to the final report summarizing "A" in not more than ten typewritten pages. This will be more detailed than a normal abstract.

- A. Complete summary of the results obtained under the program including interpretations, conclusions, and recommendations.
- B. Results and data from all tests including graphs, tables, diagrams, and photographs as necessary.
- C. A separate section containing a detailed description of the production procedure. Included shall be specific and complete descriptions of processes, formulations, equipment required, material sources, time schedules, and any other information necessary for manufacture of production quantities of the compound, including the need for, and process description of, any vacuum degassing recommended.
- D. A review of the relevance of resultant formulations to aircraft, industrial, and/or commercial applications.

A draft copy of the final report shall be submitted for review and approval by the Technical Monitor. The Contractor shall make any changes, corrections, additions, or clarifications required by the Technical Monitor prior to printing of the final report.

5.3 Cost Proposal for Additional Quantities

At the time of submission of the final report, the contractor shall submit a detailed cost proposal for supplying additional quantities of the selected compound for a period of six (6) months after completion of the contract. The quantities to be supplied shall be in lots of from 50 to 100 pounds, and the total quantity to be supplied in the six month period shall not exceed 1,000 pounds. The cost proposal shall state the net price per pound including delivery to NASA-MSC.

TABLE I
Safety Properties

<u>Property</u>	<u>T/M (1)</u>	<u>Compound Requirement</u>	<u>Test Method</u>	<u>Descriptive Paragraph</u>
Flammability	M	Self-extinguishing	Test 1, App. A	3.4.1
Offgassing	M	<100 $\mu\text{g}/\text{g}$ total organics	Test 7, App. A	3.4.2
Offgassing	M	<25 $\mu\text{g}/\text{g}$ CO	Test 7, App. A	3.4.2
Odor	M	<2.0 average score	Test 6, App. A	3.4.3

1. T.....Target

M.....Mandatory

TABLE II

Electrical and Physical Properties (1, 2)

<u>Property</u>	<u>T/M</u> <u>(3)</u>	<u>Compound</u> <u>Requirement</u>
Dielectric Constant	M	5.0, max.
Power Factor	M	0.09, max.
Dielectric Strength (50 mils)	M	350 volts/mil, min.
Volume Resistivity (ambient)	M	(P) 1×10^{12} ohms-cm., min. (C) 1×10^{12} ohms-cm., min.
Surface Resistivity	M	1×10^{12} ohms, min.
Arc Resistance	T	45 seconds, min.
Insulation Resistance (ambient)	M	100,000 megohms, min.
Insulation Resistance (212°F)	M	750 megohms, min.
Insulation Resistance (moisture cycle)	M	200 megohms, min.
Tear Strength	M	15 lb/in, min.
	T	25 lb/in, min.
Tensile Strength	T	350 psi, min.
Elongation	T	125%, min.
Shrinkage	M	1%, max. (opaque) 3%, max. (clear)
Hardness (after full cure)	M	30-85 (Shore A)
Clarity	T	Water clear
Viscosity (77°F)	T	100 to 6,000 poises
Specific Gravity	T	1.25, max.

1. Test Methods (as applicable) - Potting/encapsulating cmpds.: Appendix B
- Conformal coatings: Appendix C
2. Descriptive paragraph - P/E cmpds.: 3.4.5.1
- Conformal coatings: 3.4.5.2.
3. T.....Target
M.....Mandatory

TABLE III
Manufacturing Properties

<u>Property</u>	<u>T/M (1)</u>	<u>Compound Requirement</u>	<u>Test Method</u>	<u>Descriptive Paragraph</u>
Colorants	T	None (Detail colorants usable)		
Primers	N/A	Acceptable if other requirements met.		3.2.2
Application	M	Readily applied by an injection or extrusion gun.		3.3.2
Form	N/A	1, 2, 3, part kit if required, i.e., catalyst, resin, primer, etc.		
Pot Life Cure	T M	60 minutes, min. 30 minutes, min.	Application Life	3.3.3
Curing Time	T M ^{1,2}	6 hours 12 hours	Tack Life, max.	3.3.4
Curing Time	M	7 days	Optimum Properties, max.	3.3.4
Storage Life	M	6 months at 70°F		3.3.5
Repair and Rework	M	Required Repairability		3.3.6

1. T.....Target

M.....Mandatory

APPENDIX

- B -

MATERIAL

VENDOR

CONTACTS

APPENDIX B
VENDOR CONTACTS

Vendor	Identification		Function	Project Interest	
	Proprietary	Generic and/or Formula		Y	N
Air Products and Chemicals, Inc. Plastics Div.	No. 7021	propylene vinyl chloride copolymer (s)	thermoplastic; UL rating = SE-0		X
Allied Chemicals, Plastics Div.	PLASKON FR 1080	polypropylene	thermoplastic UL rating = SE-0		X
Aluminum Co. of America		n.r.			
Americhem, Inc.		n.r.			
Amoco Chemicals Corp. Plastics Div.	1) No. 2356 2) No. 2056	polypropylene polymers and copolymers (s)	1) thermoplastic: UL = SE-1 2) reinforced thermoplastic: UL = SE-1		X
Ampacet Corp.		n.r.			
Anderson Development Co.	withdrawing their proprietary flame retardant compounds from market.				X
A. & S. Corp.	---	ammonium sulfamate	f.r. additive	X	
Bacon Industries, Inc.		n.r.			
BASF Wyandotte Corp.		n.r.			
Borg-Warner, Marbon Div.	CYCOVIN, Grade KA	ABS/PVC copolymer	thermoplastic; UL rating = SE-0		X
	CYCOLOY KHP	ABS	thermoplastic; UL rating = SE-0		X
s-----solid	1 -----liquid	f.r. ----- fire retardant	n.r. -----no response		

B
2

APPENDIX B -(cont)
VENDOR CONTACTS

Vendor	Identification		Function	Project Interest	
	Proprietary	Generic and/or Formula		Y	N
Buckman Laboratories, Inc.	1) BUSAN 11-MI	1) modified barium metaborate (s)	1) fire and weather retardant (partial substitute for antimony oxide); mold and bacterial control.	X	
	2) BUSORB 34	2) diethyl-3-acetyl-4-hydroxybenzyl phosphonate (1)	2) f.r. (synergist for halogens); UV absorber and stabilizer		X
Canadian Industries Ltd.		n.r.			
Carborundum Co., Research & Development Div.		n.r.			
Celanese Plastics Co.		n.r.			
Chemetron Corp., Pigments Div.	Fire-Shield - AO	antimony oxide	f.r. (synergist for halogens)	X	
Cities Service Co.		n.r.			
Cincinnati Development & Mfg. Co.	INSULSTRUC X2FR-PG	polyester/fiberglass sheet (cured)	non-burning (ASTM D635)		X
Cosmic-Plastics Inc.		n.r.			
Dart Industries, Fiberfil Div.		n.r.			
Diamond Shamrock Chemical Co.	DION FR-6430 DION FR-6482	31% brominated polyester (s) brominated polyester (lower Br than FR-6430)	reactive f.r. thermosets (non-styrenated)	X	X
	DION FR-ISO-6481	flexible isophthalic		X	
	DION FR-6435	flex. bisphenol alkyd (more reactive than FR-6481) (1)		X	
s-----solid	l-----liquid	f.r.-----fire retardant	n.r.-----no response		

APPENDIX B (cont)
VENDOR CONTACTS

Vendor	Identification		Function	Project Interest	
	Proprietary	Generic and/or Formula		Y	N
Diamond Shamrock Chemical Co.(cont)	CHLOROWAX (series) (l & s)	chlorinated paraffins	f.r. additives		X
	DELVET (series) (l & s)	chlorinated paraffins	f.r. additives		X
Dover Chemical Corp.	Chlorez	chlorinated paraffins (s)	f.r. additives		X
	Paroils	chlorinated paraffins (l)	f.r. additives		X
	Rez-o-sperse	chlorinated paraffin resin dispersions and emulsions in water	f.r. additives		X
	---	tetrachlorobisphenol A (s)	f.r. reactant (epoxies, polyesters, etc.) and additive		X
ow Chemical Co.	DER-511	epoxy (s): 18-20% Br	reactive f.r. thermosets	X	
	DER-542	epoxy (s): 44-48% Br		X	
	DER-599	epoxy (l): 50-54% Br		X	
	DER-732	epoxy (l): polyglycol diep.	flexible thermosets	X	
	DER-736	epoxy (l): polyglycol diep.		X	
	DER-741	epoxy (l): --		X	
	DEH-61	epoxy hardener for DER-741	good elongation	X	
	--	ammonium bromide	f.r. additives		X
	FR-63C (s)	63% Br (s)	f.r. additives	X	
	FR-250-BA	Octabromobiphenyl (s): 81-82% Br	f.r. additives	X	
	FR-300-BA	decabromodiphenyl oxide (s): 81-83% Br	f.r. additives	X	
	FR-651-A	pentabromochlorocyclohexane (s): 77.87% Br /6.91% Cl	f.r. additives	X	
s-----solid	l-----liquid	f.r.-----fire retardant	n.r.-----no response		

B-14

APPENDIX B (cont)
VENDOR CONTACTS

Vendor	Identification		Function	Project Interest	
	Proprietary	Generic and/or Formula		Y	N
Dow Chemical Co. (cont)	FR-2406	tris (2,3-dibromopropyl) phosphate (1): 68.73% Br / 4.44P	f.r. additives	X	
	--	bromine (1)	f.r. reactive compound		X
	--	bromine chloride (1/g)	f.r. reactive compound		X
	FR-100-BA	tribromophenol (s)	f.r. reactive compound		X
	FR-1138	dibromoneopentyl glycol (s): 61% Br	f.r. reactive compound	X	
	FR-1360	tribromoneopentyl alcohol (s): 73.80% Br	f.r. reactive compound	X	
	--	tetra bromobisphenol A (s): 57.77% Br	f.r. reactive compound	X	
	--	vinyl bromide (g/l): 74.71 Br	f.r. reactive compound		X
Dow Corning Corp.	94-531	fluorosilicone polymer*	f.r. RTV: 2 component	X	
	Sylgard 170 A&B	silicone polymer	f.r. RTV: 2 component	X	
East Coast Chemicals Co.		n.r.			
Eastman Chemical Products, Inc.		n.r.			
El Monte Chemical Co.	PH 990	phosphonitrilic resin (s)	thermoset, condensation reaction, 250°F, min., cure.		X
Emerson & Cuming	Eccospheres R	glass (sodium borosilicate) microballoons (s)	f.r. additive to reduce density	X	
	Eccospheres SI	silica microballoons (s)	f.r. additive to reduce density	X	
Engelhard Minerals & Chemicals Corp.	--	aluminum silicates	f.r. fillers		X
	--	calcined clays	f.r. fillers		X
s-----solid	1-----liquid	f.r.-----fire retardant	n.r.-----no response		

APPENDIX B (cont)
VENDOR CONTACTS

Vendor	Identification		Function	Project Interest	
	Proprietary	Generic and/or Formula		Y	N
Enjay Chemical Co.	Butyl H T	chlorobutyl elastomer (s): 9.45% H/22.4% Cl	f.r. (cure: R.T. to 320°F)		X
	EPR-404 FR	ethylene propylene (s): copolymer	f.r. (cure: R.T. to 320°F)		X
	CHLOROBUTYL LM	chlorobutyl elastomer (visc.1) 9.45% H Cl/22.4% Cl	f.r. (cure: R.T. to 320°F)		X
Fiberite Corp.		n.r.			
Fine Organics Inc.	---	hexabromobenzene (s): 86.9% Br	f.r. additive	X	
	HBCD	hexabromocyclododecane (s): 74.7% Br	f.r. additive	X	
	PEBS	tribromosalicylanilide (s): 53.% Br	f.r. additive	X	
	FYR-FYTR	tetrabromosalicylanilide (s): 60.5% Br	f.r. additive	X	
GAF Corp., Chemicals Div.	---	dibromobutenediol (s)	reactive f.r.	X	
General Electric Co., Plastics Dept.		n.r.			
General Electric Co., Silicone Dept.		n.r.			
Glastic Corp.	RESISTRAC, etc.	polyester FRP (cured and and uncured)	rigid; UL = SE-0 to -1		X
GLFS Co., Mineral Products Div.	GHA-331	alumina trihydrate (s)	f.r. additive	X	
B. F. Goodrich Chemical Co.		n.r.			
s-----solid	1-----liquid	f.r.-----fire retardant	n.r.-----no response		

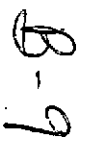
APPENDIX B (cont)
VENDOR CONTACTS

Vendor	Identification		Function	Project Interest	
	Proprietary	Generic and/or Formula		Y	N
W. R. Grace & Co., Marco Div.	GR series	brominated polyesters (1)	reactive f.r. thermosets (styrenated)		X
Great Lakes Chemical Corp.	---	1) tris (2,3-dibromopropyl) phosphate (1)	1) f.r. additive		X
	---	2) tetrabromobisphenol A	2) f.r. epoxies		X
	---	3) epibromohydrin	3) f.r. epoxies		X
Halby Chemical Co.	FLAMEOUT 5600-B-1	brominated trialkyl boron ester (high M.W.) (1): 55.0 ± 2.0% Br	f.r. additive	X	
Hardman, Inc.		n.r.			
Hercules Inc., Polymers Dept.	Pro-fax SA-595	polypropylene copolymer (s)	f.r. thermoplastic: UL rating = SE-0		X
	Pro-fax PC-842	polypropylene homopolymer (2)	f.r. thermoplastic: UL rating = SE-0		X
	Pro-fax PC-763	polypropylene for chopped glass premix (s)	f.r. thermoplastic: UL rating = SE-1		X
Hooker Chemical Corp. Industrial Chem. Div.	Dechlorane Plus 25 and 515	organic compd. (s): 65.% Cl	f.r. additive		X
	Dechlorane 510 and 4070	perchloropentacyclodecane (s): 78.% Cl	f.r. additive		X
	Dechlorane 602	organic compd. (s): 69.4% Cl	f.r. additive		X
	Dechlorane 603	organic compd. (s): 66.7% Cl	f.r. additive		X
	Dechlorane 604	organic compd. (s): 76.9% Br/Cl	f.r. additive	X	
s-----solid	1-----liquid	f.r.-----fire retardant	n.r.-----no response		

B-7

Vendor	Identification		Function	Project Interest	
	Proprietary	Generic and/or Formula		Y	N
Hooker Chemical Corp. Industrial Chem. Div. (cont)	Niagathal	tetrachlorophthalic anhydride (s): 49.6% Cl	f.r. reactive compd.		X
	HET Acid	chlorendic acid (s): 54.7% Cl	f.r. reactive compound		X
	C-56	hexachlorocyclopentadiene (1) 78.% Cl	f.r. reactive compound		X
	CP-50	chlorinated paraffin (1) 50.5% Cl	f.r. additive		X
	CP-40	chlorinated paraffin (1): 42.% Cl	f.r. additive		X
	MPS-500	stabilized chlorinated ester of a fatty acid (1): 36.% Cl	f.r. additive		X
Hooker Chemical Corp., Durez Div.	Hetron series	halogenated polyesters (1 & s)	f.r. reactive thermosets	X	
Humphrey Chemical Corp.	ZB-series	zinc borates	f.r. additives	X	
ICI America, Inc.	MONNEX	? (s)	f.r. additive	X	
Interplastic Corp., Commercial Resins Div.	CoRezyn 1664	chlorinated polyester	f.r. reactive thermoset (styrenated)		X
ISOCHEM Resins Co.	Isochemrez 402-448/1173	alumina filled epoxy	pre-vacuumed and non-dermatitic.	X	
Keil Chemical Co., Inc.	---	chlorinated and brominated paraffins and fatty cmpds.	f.r. additives and plasticizers		X
s-----solid	1-----liquid	f.r.-----fire retardant	n.r.-----no response		

APPENDIX B (cont)
VENDOR CONTACTS

Vendor	Identification		Function	Project Interest	
	Proprietary	Generic and/or Formula		Y	N
Kewanee Oil Co., Harshaw Chemical Co. Div.	Grades KR, KR-LTS, White Star, White Star 'M'	antimony oxides (various grades) (s)	f.r. additive (synergist for halogens)	X	
L N P Corp.		n.r.			
Marplex, A Hitco Co.	---	molding cmpds. & laminates	f.r.		X
Michigan Chemical Corp.	FIREMASTER Series	halogenated & phospho-halogen cmpds. (l & s)	reactive and non-reactive f.r. compounds	X	
Millmaster Chemical Co.		n.r.			
Mobil Chemical, Industrial Chemicals Div.	Vircol-82	phosphorus-containing polyol (1): 11.3% P	f.r. reactive compound	X	
	Vircol-88	phosphorus-containing polyol (1): X% P	f.r. reactive compound (for rigid systems)		X
	V-C 611	phosphorus-containing polyol (1): 16% P	f.r. reactive compound	X	
Monsanto Industrial Chemicals Co.	1) Montar	1) polychlorinated polyphenyl cmpds. (s)	1) f.r. and anti-oxidation additives		X
	2) Santicizer	2) alkyl and aryl phosphate cmpds. (l)	2) f.r. additives and plasticizers		X
	3) Phos-chek P/30	3) ammonium polyphosphate	3) f.r. additive	X	
<div style="text-align: right; margin-right: 20px;">  s-----solid </div>	1-----liquid	f.r.-----fire retardant	n.r.-----no response		

APPENDIX B (cont)
VENDOR CONTACTS

Vendor	Identification		Function	Project Interest	
	Proprietary	Generic and/or Formula		Y	I
Monsanto, Organic Chemicals Div.	Phosgard C-22-R	chlorine and phosphorus-containing organic compound (1): 27.% Cl/15.% P	f.r. additive (synergist for halogens)		X
	Phosgard 2XC-20	chlorine and phosphorus-containing organic compound (1) 35.2% Cl/10.6% P	f.r. additive (synergist for halogens)		X
Monsanto Polymers & Petrochemicals Co.		n.r.			
M&T Chemicals Inc.		n.r.			
Neville Chemical Co.	Unichlor-series	chlorinated paraffins (1 & s): 37.5-70.% Cl	f.r. additives.		X
Nichem Corp.		n.r.			
NL Industries, Pigments & Chemicals Div. B-10	---	antimony oxide (various grades)	f.r. (synergist for halogens)	X	
	ONCOR 23A	50% Sb ₂ O ₃ /50% SiO ₂	f.r. additive	X	
	ONCOR 75RA	25% Sb ₂ O ₃ /75% SiO ₂	f.r. additive	X	
	ONCOR 75RAZ	12.5% Sb as Sb ₂ O ₃ /12.5% Zn as ZnO	f.r. additive	X	
Novamont Corp.		n.r.			
Ottawa Silica Co.	#290 SIL CO SIL	silica, ground: 99.8%, SiO ₂	f.r. additive	X	
Owens-Illinois	Glass Resins	silicone polymers (3)	f.r. reactive compounds (for rigid systems)		X
Pacific Resins & Chemicals, Inc.		n.r.			

s-----solid

l-----liquid

f.r.-----fire retardant

n.r.-----no response

APPEND B (cont)
VENDOR CONTACTS

Vendor	Identification		Function	Project Interest	
	Proprietary	Generic and/or Formula		Y	N
Pearsall Corp., Pearsall Chemical Co. Div.	Types CPF and FLX	chlorinated paraffins (l & s): 40.-70.%	f.r. additive		X
	CMS-36	chlorinated saturated methyl ester (l): 36.% Cl	f.r. additive		X
	CMT-36	chlorinated unsaturated methyl ester (l): 36.% Cl	f.r. additive		X
Pennwalt Corp.		n.r.			
Philadelphia Quartz Co.	---	soluble silicates (s)	f.r. fillers		X
Hillips Petroleum Co.	---	styrene-butadiene elastomers (s)	elastomeric additive		X
Plastics Engineering Co.		n.r.			
Podell Industries, Inc.	"...our products....."	would not be suitable for your use."	f.r. additives		X
Polymer Materials Inc.		n.r.			
Powhatan Mining Co.	Powminco Grade 25 PM	asbestos fiber (anthophyllite) (s)	f.r. filler	X	
Premix, Inc.	---	rigid FRP cmpds and moldings	electrical insulation and structural		X
Pultrusions Corp.	GLASPUL	polyester/fiberglass laminates	---		X
K. J. Quinn & Co., Inc.	TE-3011	emulsion copolymer	f.r.		X
Raychem Corp.		n.r.			
s-----solid	l-----liquid	f.r.-----fire retardant	n.r.no response		

APPENDIX B (cont)
VENDOR CONTACTS

Vendor	Identification		Function	Project Interest	
	Proprietary	Generic and/or Formula		Y	N
Reed Plastics Corp.		flame retardants dispersed in thermoplastic media			X
Ren Plastics, Inc.		n.r.			
Rogers Corp.		n.r.			
Rohm and Haas Co.		n.r.			
Eli Sandman Co.		n.r.			
Stauffer Chemical Co.	---	triethyl borane (1): (toxic, pyrophoric)	reactive f.r.		X
	---	trimethoxy boroxines or methyl metaborate (T): (toxic, flammable)	reactive f.r.		X
	FYROL CEF	tris (beta chloroethyl)phosphate (1)	f.r. additive		X
	FYROL FR-2	tris (dichloropropyl) phosphate (s)	f.r. additive		X
	FYROL 32B & FYROL HB32	tris-2,3-dibromopropyl phosphate (1)	f.r. additive		X
	CELLUFLEX, LINDOL, & PHOSFLEX	tricresyl phosphate tritoyl phosphate (1)	f.r. additive		X
	PHOSFLEX T-BEP	tributoxyethyl phosphate (1)	f.r. additive		X
	---	dimethyl phosphite or dimethyl phosphonate (1)	reactive f.r.		X
	---	diethyl phosphite or diethyl phosphonate (1)	reactive f.r.		X
	---	dibutyl phosphite or dibutyl phosphonate (1)	reactive f.r.		X
	---	di-isopropyl phosphite or di-isopropyl phosphonate (1)	reactive f.r.		X
	---	dioctyl phosphite or di-2-ethyl hexyl phosphite or di-2-ethyl hexyl phosphonate (1)	reactive f.r.		X

s-----solid

l-----liquid

f. r. -----fire retardant

n.r. -----no response

B-12

APPENDIX B (cont)
VENDOR CONTACTS

Vendor	Identification		Function	Project Interest	
	Proprietary	Generic and/or Formula		Y	N
Stauffer Chemical Co. (cont)	---	Diphenyl phenyl phosphonate (s)	reactive f.r.		X
	FYROL HMP	di (polyoxyethylene) hydroxy-methyl phosphate	reactive f.r.		X
	FYROL 6	diethyl N, N-bis (2-hydroxy-ethyl) amino methyl phosphonate (1)	reactive f.r.	X	
	---	bis (beta-chloroethyl) beta-chloroethyl phosphonate (1)	reactive f.r.		X
	---	diallyl chloromethyl phosphonate	reactive f.r.		X
	FYROL Bis-Beta	bis (beta-chloroethyl) vinylphosphonate or vinylphosphonic acid, bis (2-chloroethyl) ester or bis (2-chloroethyl) vinyl phosphonate	reactive f.r.	X	
	FYROL 99	26% chlorine/14% phosphorus (1)	f.r. additive		X
	CMPA	chloromethyl phosphonic acid (1-85% soln. or s-97%)	reactive f.r.		X
	CMPD	chloromethyl phosphonic dichloride (1)	reactive f.r.		X
	---	phenylphosphonous dichloride	reactive f.r.		X
Swift Chemical Co.	---	diphenylphosphinous chloride or diphenyl chlorophosphine (1)	reactive f.r.		X
	SILBOND Series	ethyl silicates	reactive f.r. (forms rigid mat'ls)		X
	Brominex 160P	brominated polyol containing phosphorus	reactive f.r.	X	
Symplastics, Inc.	1) Sympoxy 1531	1) epoxy	1) f.r. dip coating	X	
	2) Sympoxy 1550	2) epoxy	2) f.r. conformal coating	X	
Synthane-Taylor Corp., Haysite Div.		n.r.			
s-----solid	l-----liquid	f.r.-----fire retardant	n.r.-----no response		

APPENDIX B⁺ (cont)
VENDOR CONTACTS

Vendor	Identification		Function	Project Interest	
	Proprietary	Generic and/or Formula		Y	N
Tra-Con Inc.		n.r.			
United States Borax & Chemical Corp.	FIREBRAKE ZB	$2ZnO \cdot 3B_2O_3 \cdot 3.5H_2O$	f.r. additive	X	
U. S. I. Chemicals Co.		n.r.			
Universal Oil Products Co.	CLORAN	difunctional carboxylic acid anhydride (s): 50.2% Cl	reactive f.r.		X
Wellman, Inc.	1) Wellamid FR22F- N 6600 G.P.	1) epoxy compd. ?	f.r.; UL = SE; very low elongations		X
	2) Well-Sphere FRGS 25-66	2) epoxy compd. ?			X
	3) Well-Sphere Blend FRGS 25-66/6	3) epoxy compd. ?			X
	4) Well-A-Meld Blend FR-GSF 25/10-66/6	4) epoxy compd. ?			X
Weston Chemical Inc.	---	alkyl, aryl, and alkyl-aryl phosphonites, phosphates, and phosphonates (l & s)	reactive and non-reactive f.r.	X	X
White Chemical Corp.	---	brominated intermediates	f.r.	X	
Velsicol Chemical Corp.	---	chlorendic anhydride (s): 54.5% Cl	f.r. reactive compound		X
	---	dimethyl chlorendate (s): 50.7% Cl	f.r. additive		X
	PCL	hexachlorocyclopentadiene (l): 78.4% Cl	f.r. reactive compound		X
	Douse 499	organic compd. (s): 42.7% Cl/ 32.4% Br	f.r. additive	X	
s-----solid	l-----liquid	f.r.-----fire retardant	n.r.-----no response		

6-14

APPENDIX

-C-

FORMULATION/PROCESSING

DATA SHEET

T

;

1 2

1 2

Weight

OF

O_F.

Tooling:

OF.

O.F.

Coar

Spec

Spindle:

OF

OF.

OF

days

Date:

CHARACTERISTICS
-CURED/POST CURED-

	A	B	C
1. Demolding			
2. Cured			
3. Tacky			
4. Flexible			
5. Memory			
6. Cohesion			
7. Tear resistance			
8. Crack resistance (1)			
9. Crack propagation (1)			
10. Porous			
11. Adheres to unclean alum. foil cup			
12. Cheesy			

Y.....Yes
N.....No

X.....Satisfactory
F.....Fair

VS.....Very Slight
S.....Slight

P.....Poor
NG.....Not Good

1. 180° bend (face-to-face contact)

APPENDIX

- D -

UPWARD

PROPAGATION

TEST (1)

1. Test No. 1 of NHB 8060.1, "Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments that Support Combustion ", NASA Office of Manned Space Flight, Nov. 1971 Edition.

401 TEST NO. 1 - UPWARD PROPAGATION TEST

1. PURPOSE

The purpose of the upward propagation test is to determine the flammability characteristics of candidate materials when exposed along the bottom edge to an energized ignition source. Determination shall be made during the tests as to the sample's combustibility, self-extinguishing properties, and total burn time if not self-extinguishing.

2. CRITERIA OF ACCEPTABILITY

Materials determined noncombustible or self-extinguishing before 6 inches of the sample is consumed in the vertical position with no sparking, sputtering, or dripping flaming particles when exposed to an energized ignition source placed at the bottom of the sample for a period of 30^{+20}_{-10} seconds shall be classified as Group I. Materials that fail the above criteria shall be subjected to Test No. 2.

3. TEST CONDITIONS-PRESSURES AND ATMOSPHERE

The test shall be conducted at the most hazardous test pressure and gas mixture conditions designated for each program.

4. TEST EQUIPMENT

The test shall be conducted using the following equipment:

- a. Chamber. The test chamber shall have a volume sufficient to assure complete combustion of the sample under test. The test chamber shall have a minimum volume of 98 liters and shall be suitably constructed and protected to ensure safe operation. A window or viewing port for visual observation shall be included. The test chamber shall contain inlets for vacuum, an ignition wire, instrumentation, and test gas mixture. The chamber shall be fully protected against the possibility of operator injury in the event of explosive rupture. Organic materials used in the construction of the chamber, such as gaskets and seals, shall

be of a type that contribute little or no outgassing to the chamber or that can be pre-outgassed by vacuum cycling to a minimal identifiable amount (less than 10 parts per million (ppm) based on chamber volume). A vertical sample holder as specified in paragraph 401.4.d below shall be positioned within the test chamber.

- b. Pressure Gage. A pressure gage capable of measuring operating pressures with an accuracy of 0.1 psia or a pressure transducer and recorder with comparable capability shall be used.
- c. Oxygen Supply. Oxygen used in conducting the test shall be commercially available and shall conform to Specification MIL-O-27210, Type 1, or MIL-P-25508, Type 1. Equipment used to transfer the oxygen to the test chamber shall be efficient and safe.
- d. Sample Holder. The sample holder shall consist of a vertically mounted steel clamp that overlaps 1/4-inch on each side of a specimen along the full 12-inch minimum length of the sample, leaving a 2-inch wide by 12-inch long exposed center section. The sample material shall be located in the sample holder such that the bottom of the sample materials is located at least 3 inches from the chamber base to preclude the aid in propagation derived from a build-up of burning residue.
- e. Ignition Source. Ignition of the sample shall be accomplished by employing a regulated energy source. The ignition source shall consist of a length of No. 20 gage bare nichrome wire, which has a nominal resistivity of 0.7 ohms per foot, sufficient to wind six to eight turns around a standard silicone ignitor* or equivalent. To be considered equivalent to a silicone ignitor an alternate ignitor shall provide a flame temperature in excess of 1500°F, a flame duration of 25 \pm 5 seconds, and a flame envelope 1 x 1/2 x 1 inch. The alternate ignitor shall not drip, sputter, or otherwise expel flaming particles. At least one inch of wire shall be left at each end to permit fastening to the power source lugs. The ignition of the ignitor shall be accomplished by employing a 12-volt regulated direct current power source. The ignitor shall be placed approximately 0.25 inch from the bottom edge of the sample.

*The silicone rubber rod shall be prepared according to the following procedure:

82.5 parts by weight RTV-560 shall be blended with 17.5 of RTV-577. To the mix, 0.5 parts by weight of Thermolite T-12 shall be added and thoroughly mixed. The blend shall be immediately deaerated in a vacuum of not less than 28 inches mercury for a period of not more than ten minutes. The compound shall then be cast in a mold that will provide rods, when cured and finished, of 0.22 inch diameter and

1.25 inch length. The compound shall be cured either for 24 hours at room temperature or for four hours at room temperature followed by 10 hours at $130 \pm 10^{\circ}\text{F}$. The cured material shall show a Shore A durometer reading of not less than forty (40).

All materials required for formulating the silicone ignitor insert can be purchased from the General Electric Co., Silicone Products Dept., Waterford, New York. Ignitors prepared more than three months before use shall be disqualified.

- f. Propagation Indicators. Motion picture records shall be evaluated and retained on each propagation test. The camera shall be 16mm, operating at a rate suitable to provide an accurate indication of the test. The equipment shall be calibrated to the manufacturer's specifications and shall be positioned such that an accurate determination of the total burn characteristics can be made from the films.
- g. Propagation Timers. All burning tests shall be visually observed for ignition and combustion characteristics. A stop watch shall be started at the first visual indication of combustion and stopped when the flame front reaches the top of the sample or the sample self-extinguishes, whichever occurs first.

5. SAMPLE PREPARATION

Samples shall be prepared for test as follows:

- a. Inspection, Cleaning, Marking. Material samples shall be evaluated in the thickness intended for use and shall be free of cuts, abrasions, or other flaws as determined by close visual inspection. Before testing, the samples shall be cleaned by brushing or by flowing an inert gas over them to remove loose surface contamination. Gage marks (wire or fiberglass threads) shall be placed across the samples at one inch intervals starting at the bottom of the sample.
- b. Sizing. Sizing shall be accomplished in accordance with the following:
 - (1) Films, fabrics, sheets, and composites shall be tested in the "as received" condition. Samples shall be cut in the form of rectangles $2\frac{1}{2}$ inches wide by 12 inches long.
 - (2) Primers, coating materials, paints, and pressure sensitive tapes shall be applied either on three (3) mil thick aluminum foil or the substrate material intended for use if known. The coating shall be applied in a thickness equivalent to normal use and post cured in accordance with prescribed manufacturing practices.

- (3) Fluids and greases shall be applied to a suitable noncombustible substrate such as five (5) millimeters thick fiberglass cloth. The substrate shall be allowed to soak in the fluid for a period of 30 minutes. Greases shall be applied to the substrate in a thickness of ten (10) mm.

Note: Materials and components that will be used in an irregular size or shape shall be tested in the "as purchased" configuration. Such samples shall be attached to the sample holder by fiberglass or metal threads when the sample cannot be held by the sample holder. This includes coaxial cable, thermocouple wire, other low energy signal wiring, and electrical wiring.

6. PRETEST PROCEDURE

The following pretest checks shall be performed before test start:

- a. Verify that all test equipment is clean and is in current calibration, and that analytical equipment is calibrated and operative.
- b. Observe placement of motion picture camera(s).
- c. Verify that oxygen conforms to the classification specified in paragraph 401.4.c.
- d. Verify that sample is correctly identified.
- e. Prepare three (3) samples as specified in paragraph 401.5.
- f. If samples are irregularly shaped, describe the shapes.
- g. Weigh the samples and record the weight.
- h. Record volume of the test chamber in liters.
- i. Mount the sample in the sample holder and verify that the exposed center section is 2.0 ± 0.1 inches wide.
- j. Position the sample holder within the chamber.
- k. Place the ignitor horizontally 0.25 ± 0.03 inches from the bottom of the sample at the midpoint of the 2 inch exposed width.

7. TEST PROCEDURE

Testing of the candidate samples shall be accomplished in accordance with the following procedure:

- a. Evacuate the chamber to less than 0.1 psia.
- b. Isolate the chamber and monitor the pressure for one minute. Testing shall not begin until all leaks are corrected (a leak is indicated if an increase in pressure of more than 0.1 psia occurs in five minutes).
- c. Pressurize the chamber with test gas mixtures at the maximum use pressure.
- d. Verify composition of the test gas mixture using analytical methods that are accurate and appropriate for the test conditions.
- e. Allow the chamber to stabilize at the test pressure, then soak the samples in test gas mixture for a period of at least three minutes.
- f. Verify that the chamber pressure is the desired test pressure, then isolate the chamber.
- g. Start the motion picture camera and other applicable instruments.
- h. Apply current to the ignition wire until the silicone rod ignites.
- i. Record whether sample is noncombustible, self-extinguishing, and/or extent of burning.
- j. Note combustion characteristics (nature and color of flame, soot, residue and other pertinent observations).
- k. Record the final pressure in the chamber and the final temperature rise.
- l. Secure the chamber.

8. REPORTING

The data shall be reported in accordance with instructions contained in paragraph 208 on a form similar to Figure 2-1. The following data are required for this test:

- a. Name and positive identification of the material.
- b. Vendor designation and vendor.
- c. Self-extinguishing, or propagation in inches per second.
- d. Combustion Characteristics. Distance that flame progressed before extinguishing, flame phenomena and temperature, etc.
- e. Disposition or status, dimension, and size of sample material.

- f. Name and number of test procedure.
- g. Test pressure and test atmosphere.
- h. Date of test.
- i. Test number.
- j. Identification of the testing agency.
- k. Name and signature of test coordinator.
- l. Thickness.
- m. Substrate material if used.

A P P E N D I X

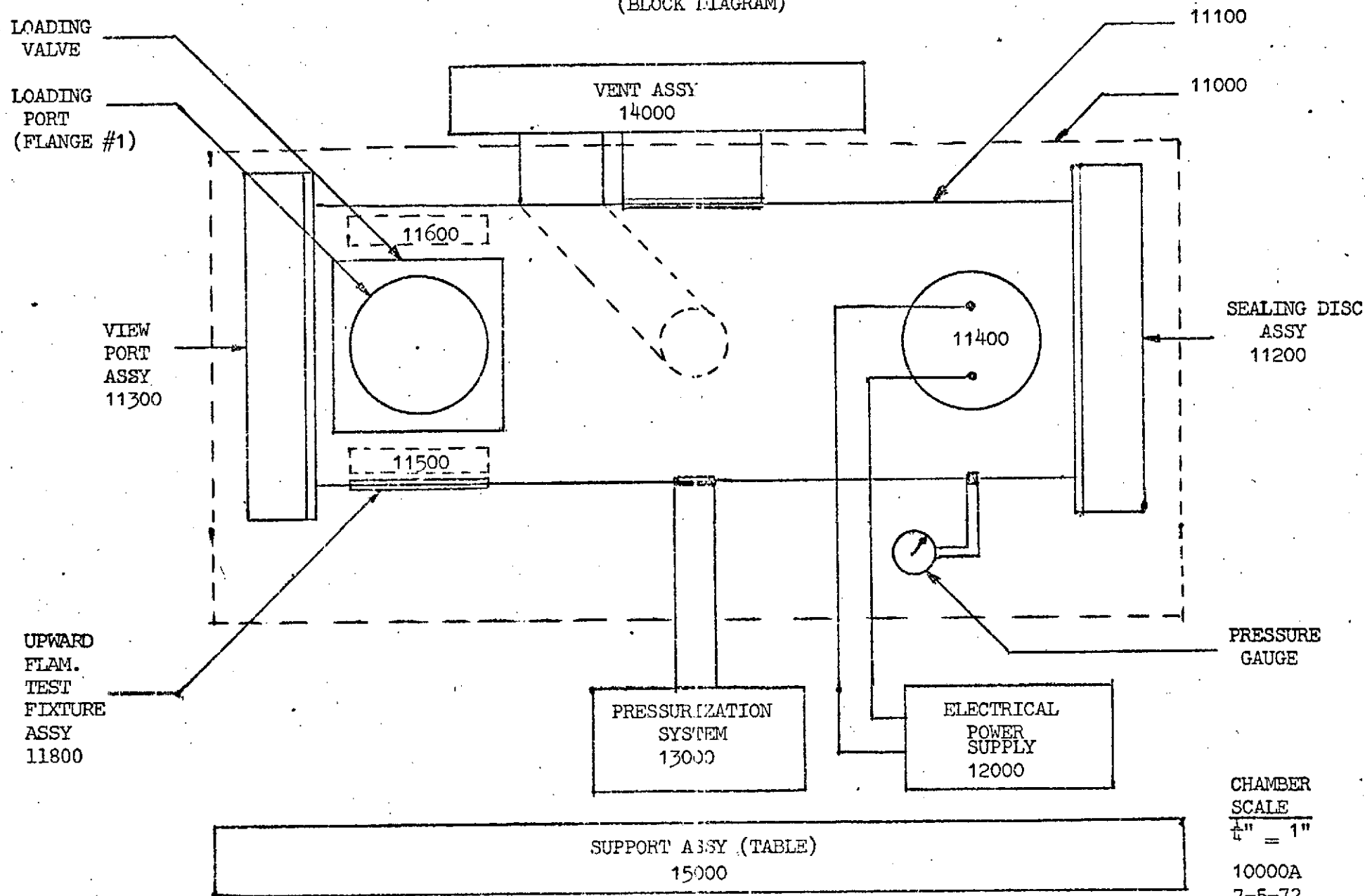
- E. -

Reproduced from
best available copy.



NASA/FURANE
FLAMMABILITY
TEST FACILITY

FIGURE 1
FLAMMABILITY TEST FACILITY
(BLOCK DIAGRAM)



CHAMBER
SCALE
 $\frac{1}{4}'' = 1''$
10000A
7-5-72
SLL

TABLE 1
LEGEND
(See Figure 4)

Schematic

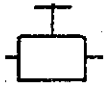
Name



Bellows line



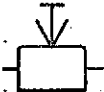
Copper tubing



Pressure valve (manual)



Check valve



Vacuum valve (manual)



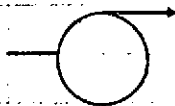
Regulator



Gauge



Pressure switch



Vacuum pump



Burst diaphragm



Light



110 v. AC power feed



Gas cylinder



Filter

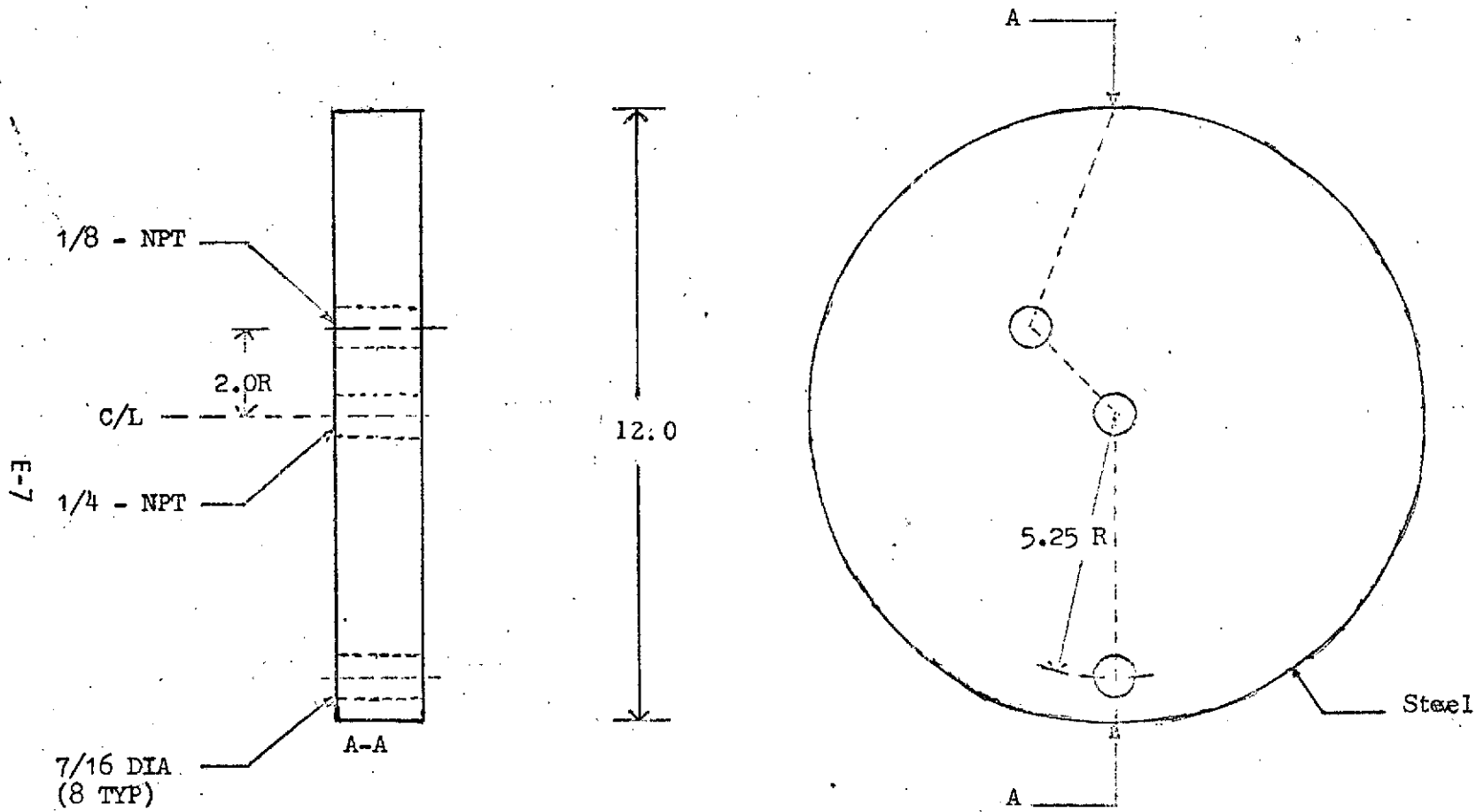
TABLE 2
BILL OF MATERIALS
(See Figure 2)

<u>PART NO.</u>	<u>REQ/ASSY.</u>	<u>MATERIAL/COMPONENT</u>	<u>STOCK SIZE</u>
-1	1	Mechanical Vacuum Pump	KC-8 (Kinney)
-2	1	Stainless Steel	4 Liter Flask
-3	1	TG Transducer Gland with I/C Thermocouple	MTG-20-A4 (Conax)
-4	1	Temperature Recorder	Mod. 122 (Rust Rak)
-5	1	P/N 14100	
-6	1	N ₂ Container	1A (hi-pressure)
-7	1	O ₂ Container	1A (hi-pressure)
-8	1	Bellows Copper Tubing with Flange and Pipe Fittings	1" I.D. x 3'
-9	1	S.S. Bellows with Wire Overwrap	2.0" OD x 20.6" L
-10	1	T-304 Tubing	3.0" OD x .083 W x 34.74 L
-11		Copper Tubing	1/4" diameter, length as required
-12	2	Valve	Type 11-010-027 (Norgren)
-13	1	Valve	Mod. 40 AE 50 (Moore)
-14	1	Valve	Mod. 40 AE 30 (Moore)
-15	2	Valve	1/4" Mod. 400 WOG (Lunkenheimer)
-16	1	Valve	1/4" Mod. 180 (Powell)
-17	1	Valve	1/4" RB 493 (Hoke)
-18	1	Valve	2" VST - 22M2 (CVC)
-19	1	Valve	1/4" 4112-MAY (Hoke)
-20	1	Valve: Brass with Copper Bellows	1-1/2" (Veeco)

TABLE 2 (continued)

<u>RT NO.</u>	<u>REQ/ASSY.</u>	<u>MATERIAL/COMPONENT</u>	<u>STOCK SIZE</u>
-21	1	Valve	1/4" A432 (Hoke)
-22	2	Gauge: 0-3,000 psi	683 (Motometer)
-23	1	Gauge: 0-5 psi	(U.S. Gauge)
-24	1	Gauge: 0-5 psi	(Marshalltown)
-25	1	Gauge: 0-30 inches	(Marshalltown)
-26	1	Gauge: 0-20 psi	FA145181 (Wallace & Tiernan)
-27	1	12-25 micron bronze element	3545 (Hoke)
-28	2	Tank Valve	(Airco)
-29	1	Check Valve	230B (Circle Seal)
-30	1	Pressure Switch	68000 (Hoke)
-31	1	Red Flood Light	100 PAR/P (G.F.)
-32	1	High Intensity Lamp	8034 (Lightolier)
-33	2	Gauge: 0-200 psi	2 1/2 - 1009 KGS (Ashcroft)
-34	2	Cable: Automotive Battery	Open Source
-35	1	Ammeter: 150A	(Simpson)
-36	2	Main Ckt. breaker	Open Source

FIGURE 3
SEALING DISC ASSY.



11200
1/21/69
S.L.L.

FIGURE 4
VIEWPORT ASSY

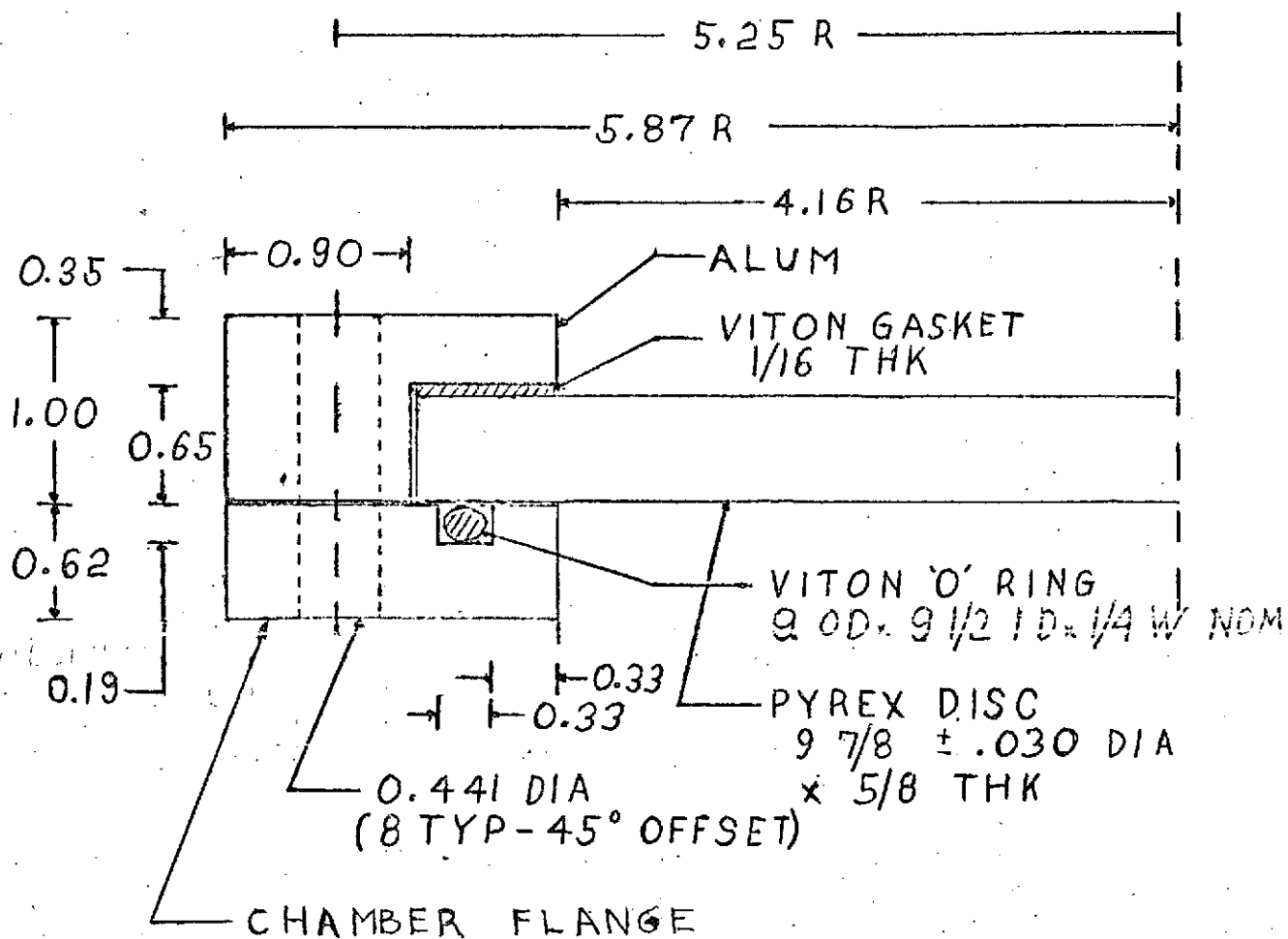
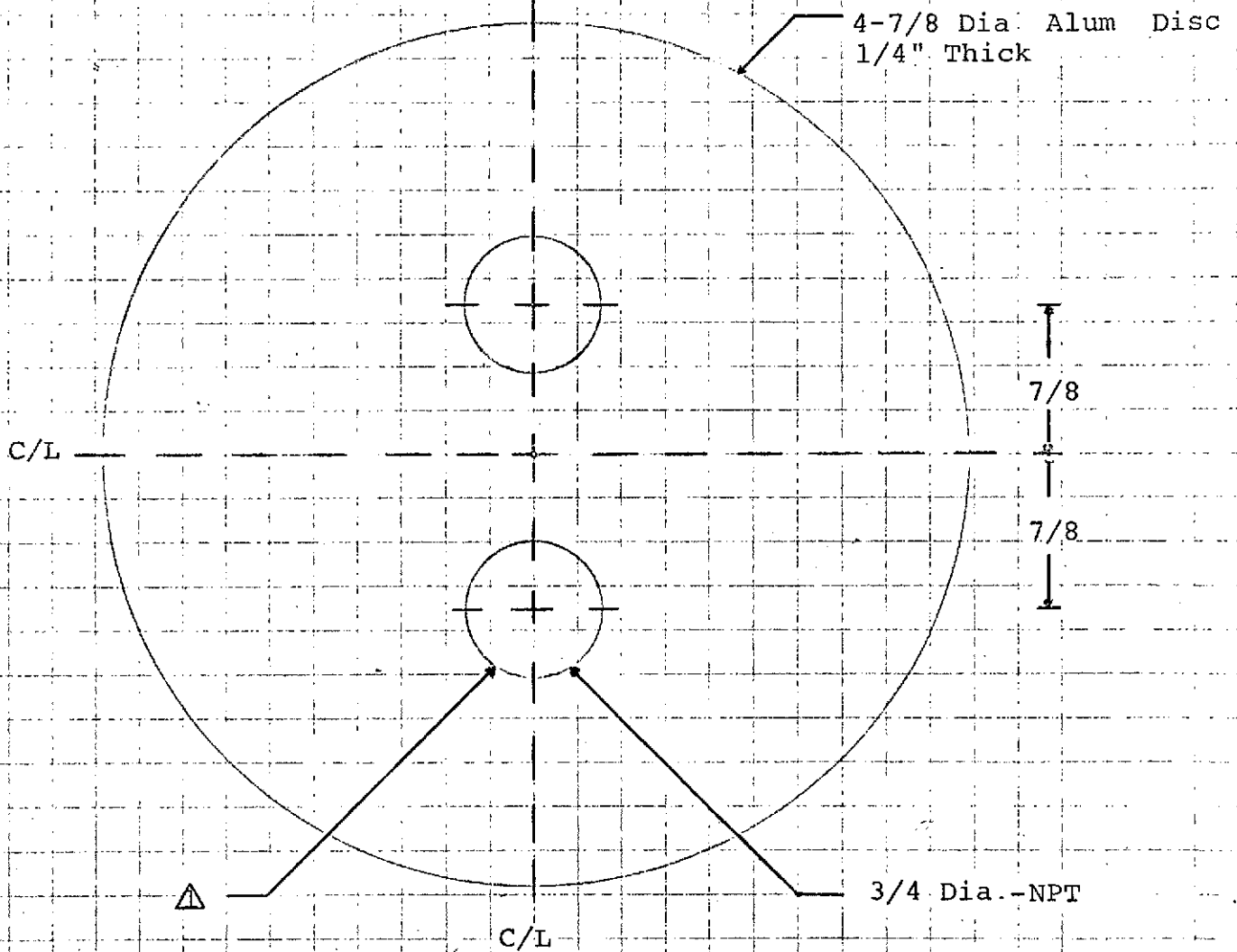


FIGURE 5

P/N 11400A

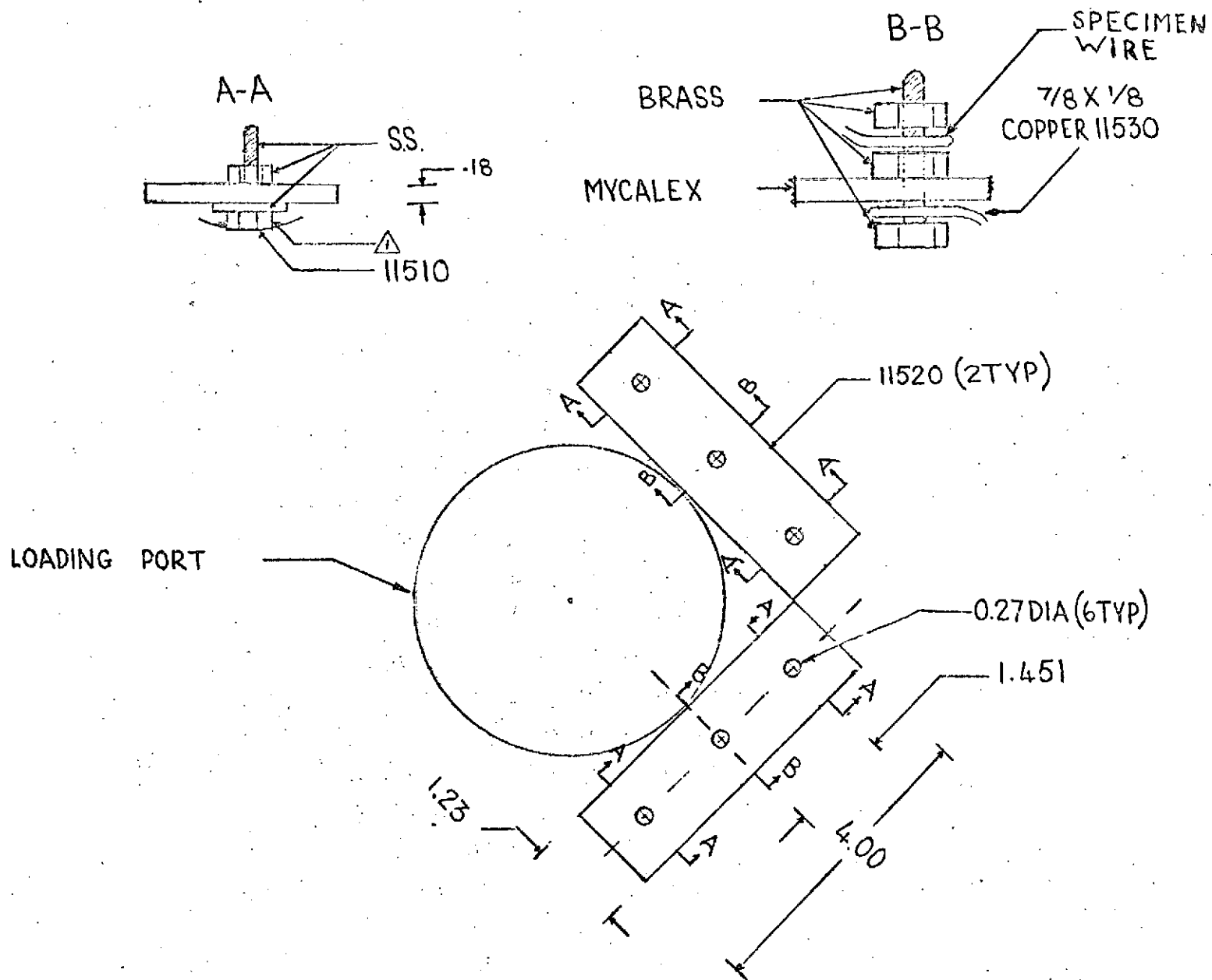
DC POWER FEEDTHROUGH



NOTE:

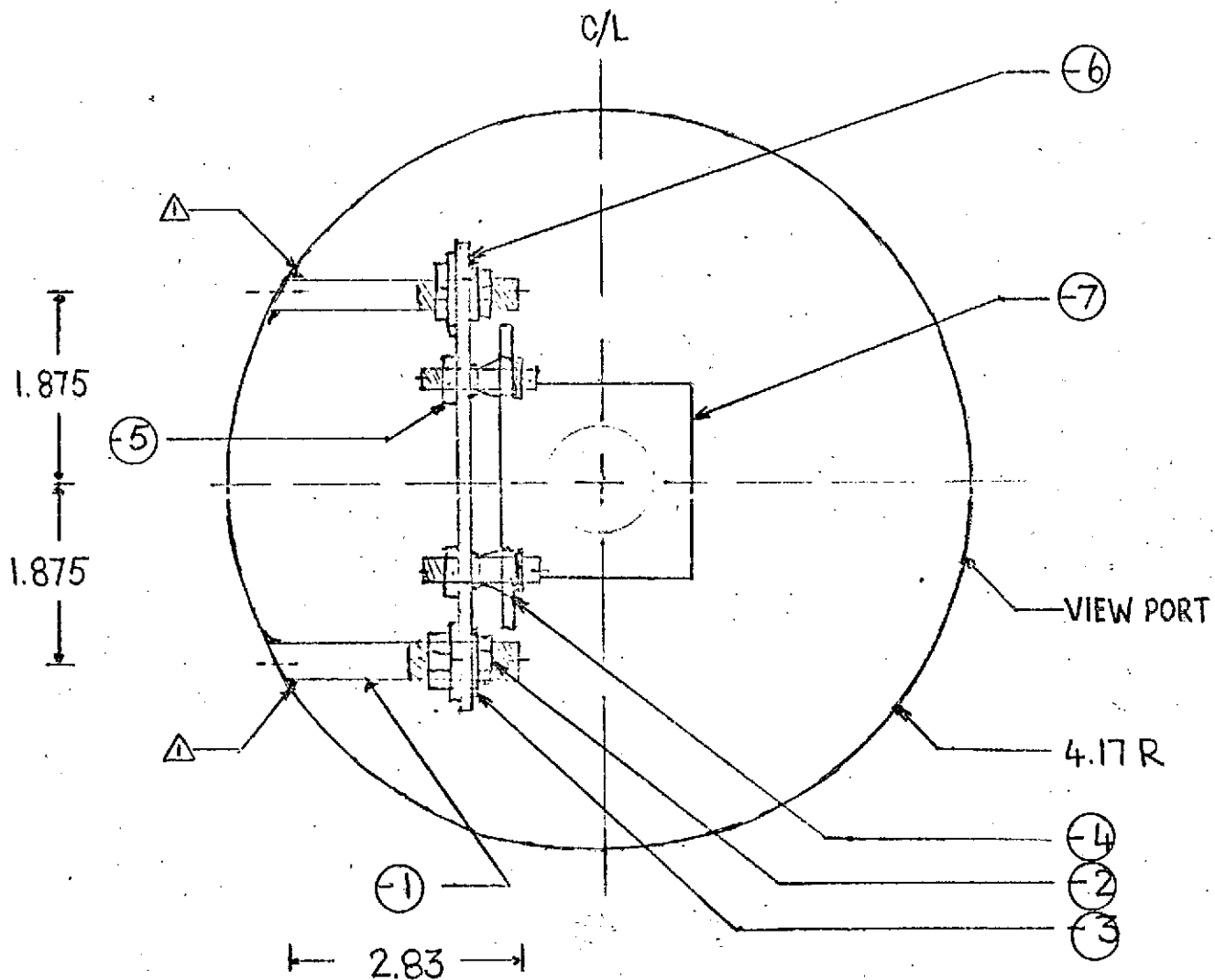
- ⚠ Using teflon sealing tape on threads, mount EGT-375-A-CU electrical conductor sealing gland (Conax Corp) in each hole. Torque to 90-100 ft -lbs

FIGURE 6
SPECIMEN POWER ASSY.
P/N 11500



NOTE:
△ WELD BOLT HEADS TO P/N 11100

FIGURE 7
SPECIMEN HOLDING FIXTURE ASSEMBLY
P/N 11600



NOTE:

△ WELD AS REQUIRED

BILL OF MATERIAL

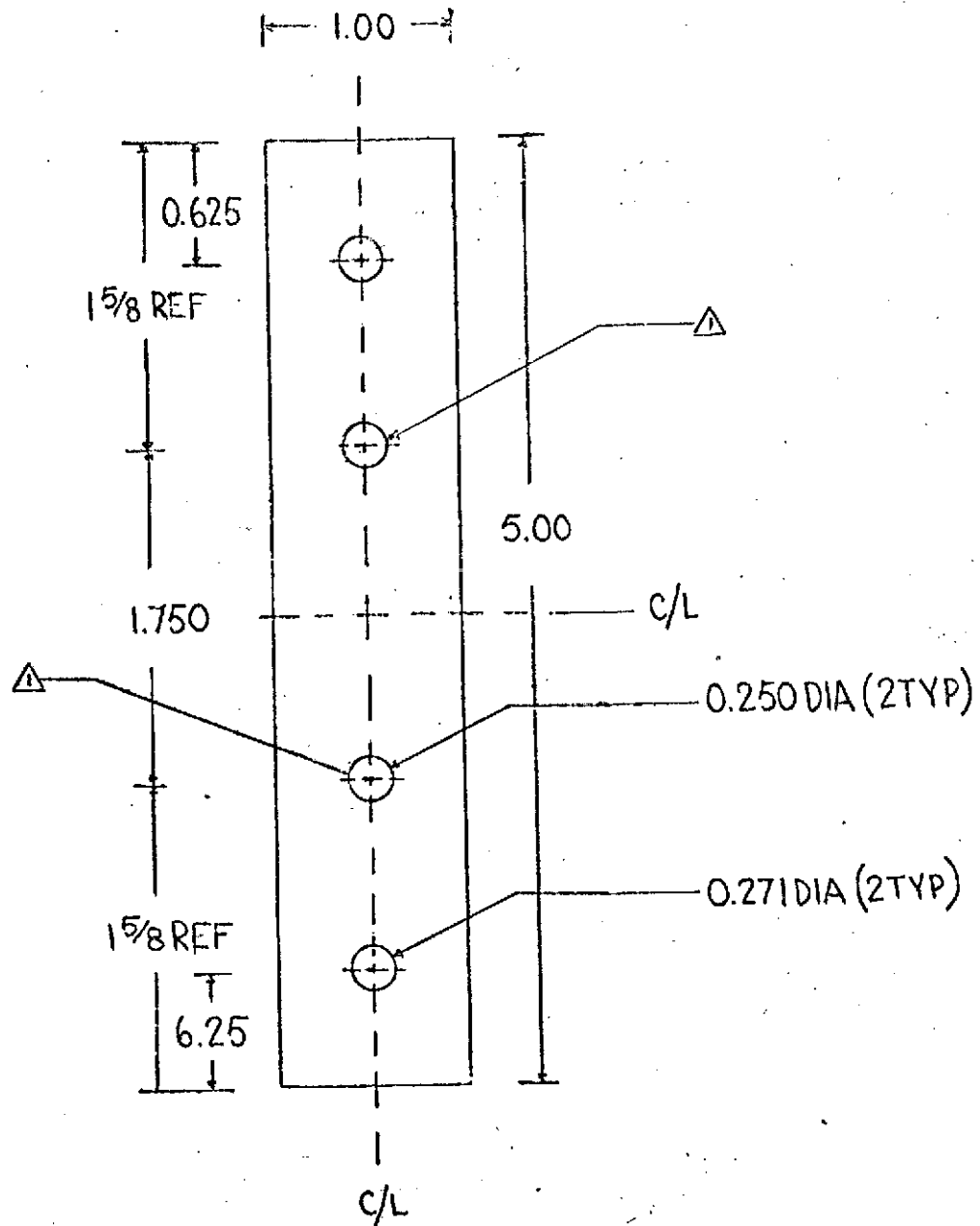
<u>PART N°</u>	<u>REQ/ASSY</u>	<u>MATERIAL</u>
-1	2	SS. BOLT
-2	4	SS. NUT
-3	4	SS. WASHER
-4	2	BANANA PLUG - MALE
-5	2	BANANA PLUG - FEMALE
-6	1	P/N 11620
-7	1	P/N 11630

STOCK SIZE
 2.83" LX 1/4-20 LAST 0.87"
 1/4-20

P/N 33-058 (GC. ELECTRONICS)
 P/N 33-192 (GC. ELECTRONICS)

FIGURE 8

SPECIMEN HOLDER SUPPORT PLATE



NOTE:

MOUNT BANANA JACK
P/N 33-192 (G.C. ELECTRONICS)

TOLERANCE
.XX \pm .030
.XXX \pm .010

MATERIAL
ALUM, 1/8" THK

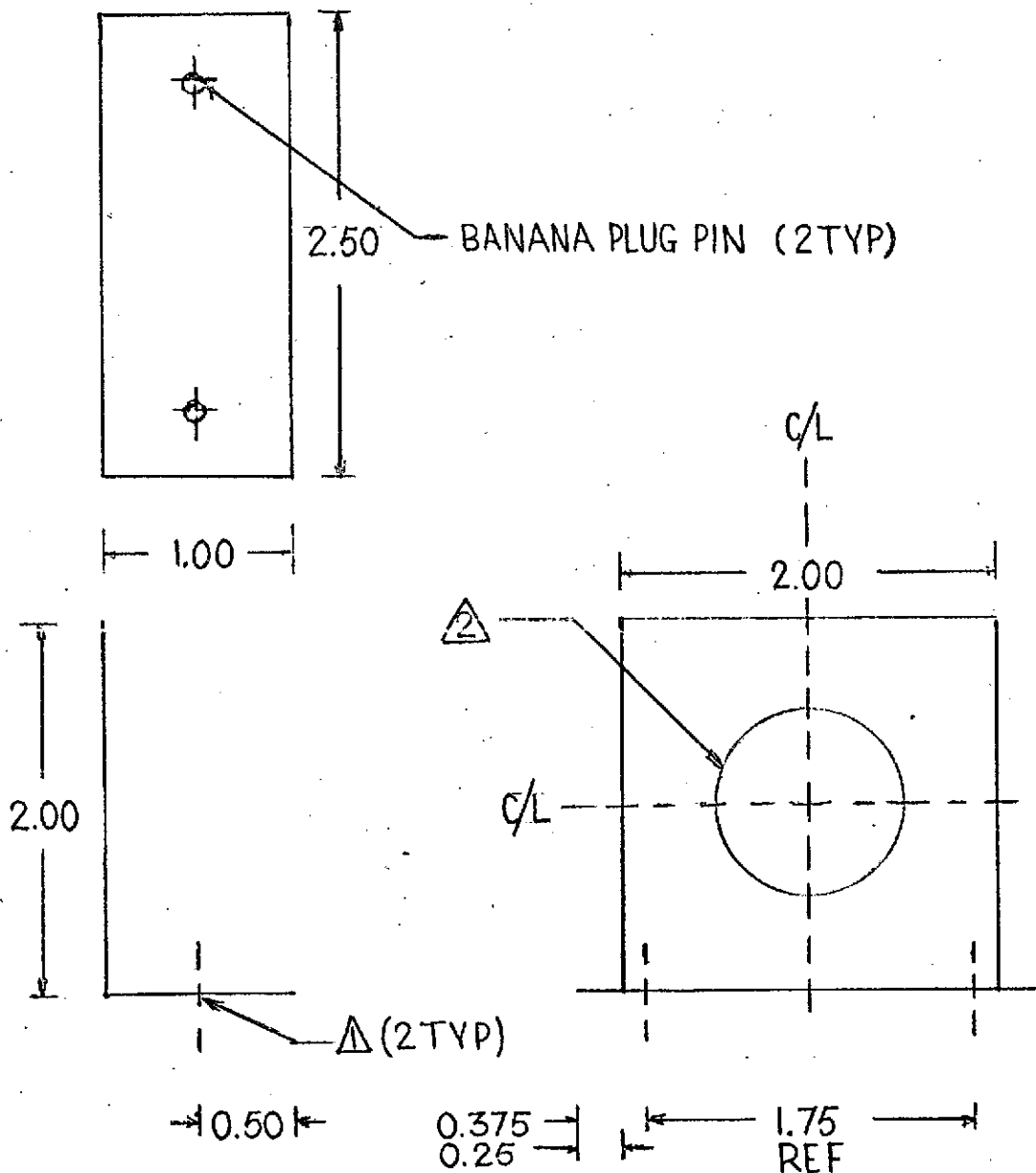
11620

E-12

S.L.L.

1-4-69

FIGURE 9
CONNECTOR HOLDER



NOTE :

- Δ DRILL FOR 8-32 THREADED
END OF BANANA PLUG PIN
- 33-058 (G.C. ELECTRONICS)
- Δ DRILL TO FIT BENDIX PYGMY CONNECTOR

TOLERANCE :

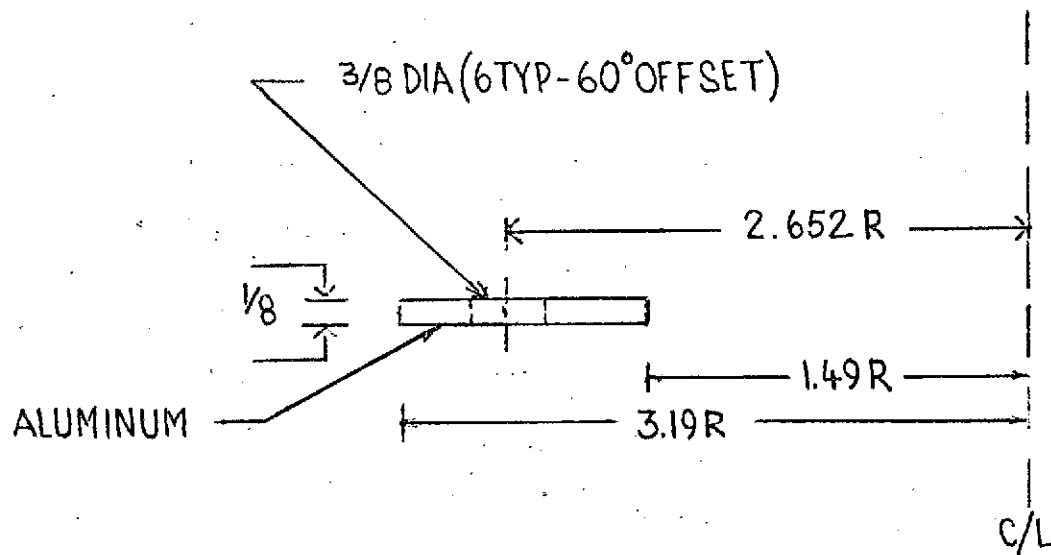
.XX ± .030
.XXX ± .010

MATERIAL :

0.040 ALUMINUM OR
ALCLAD

FIGURE 10

P/N 11700: LOADING VALVE 'O' RING INTERFACE RING



S.L.L.
12-2-68

FIGURE II
VENT ASSY
(BLOCK DIAGRAM)

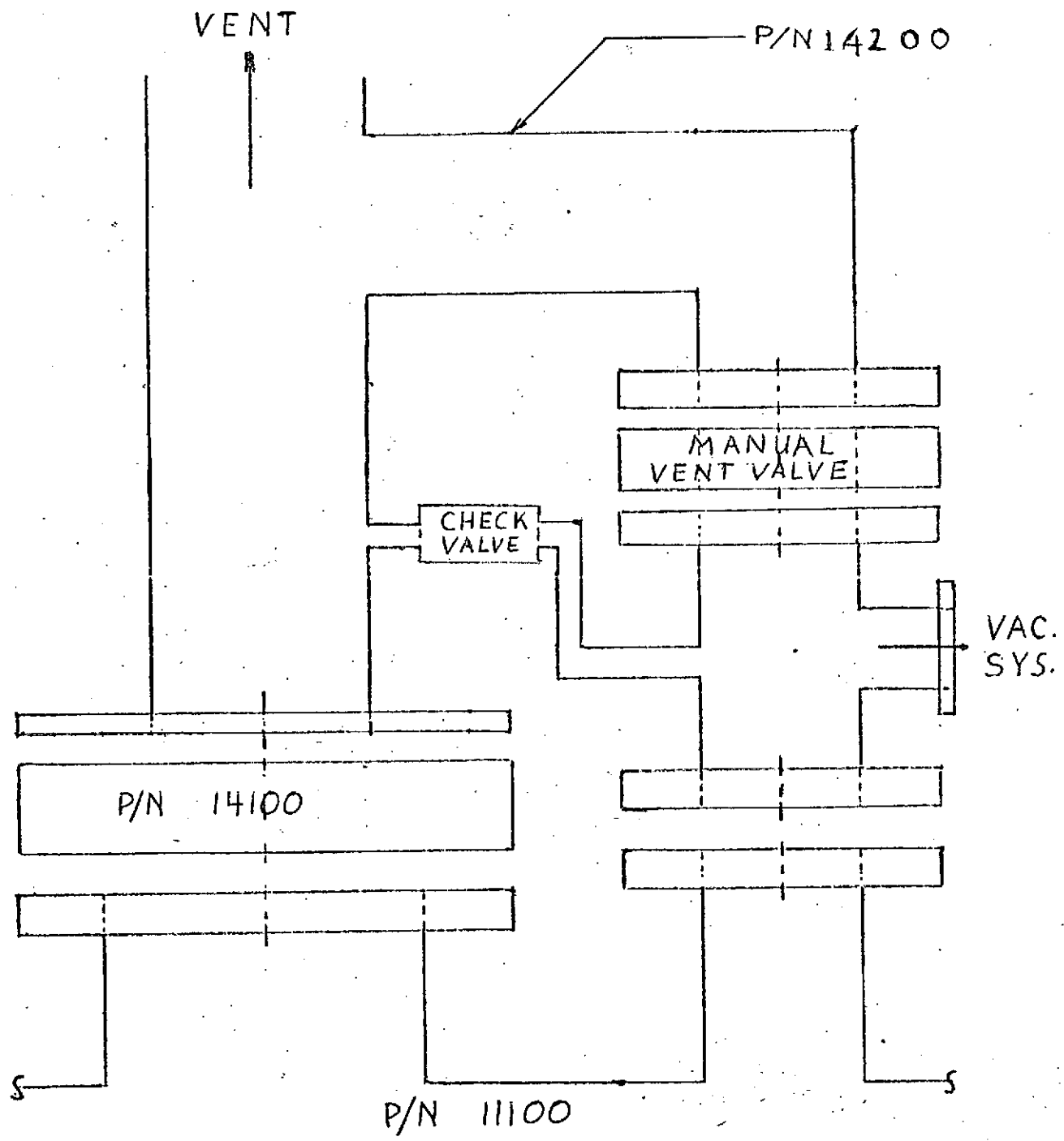
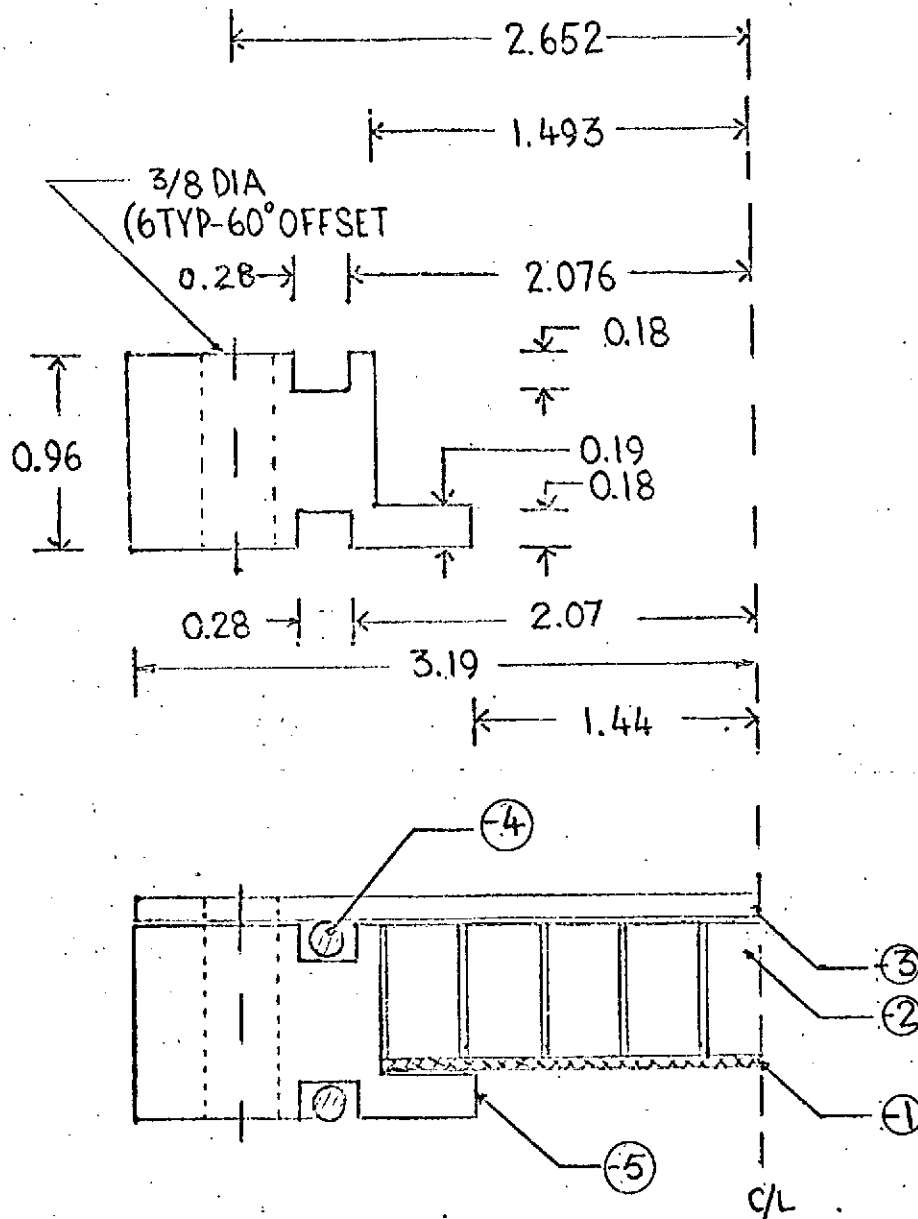


FIGURE 12

P/N 14100A

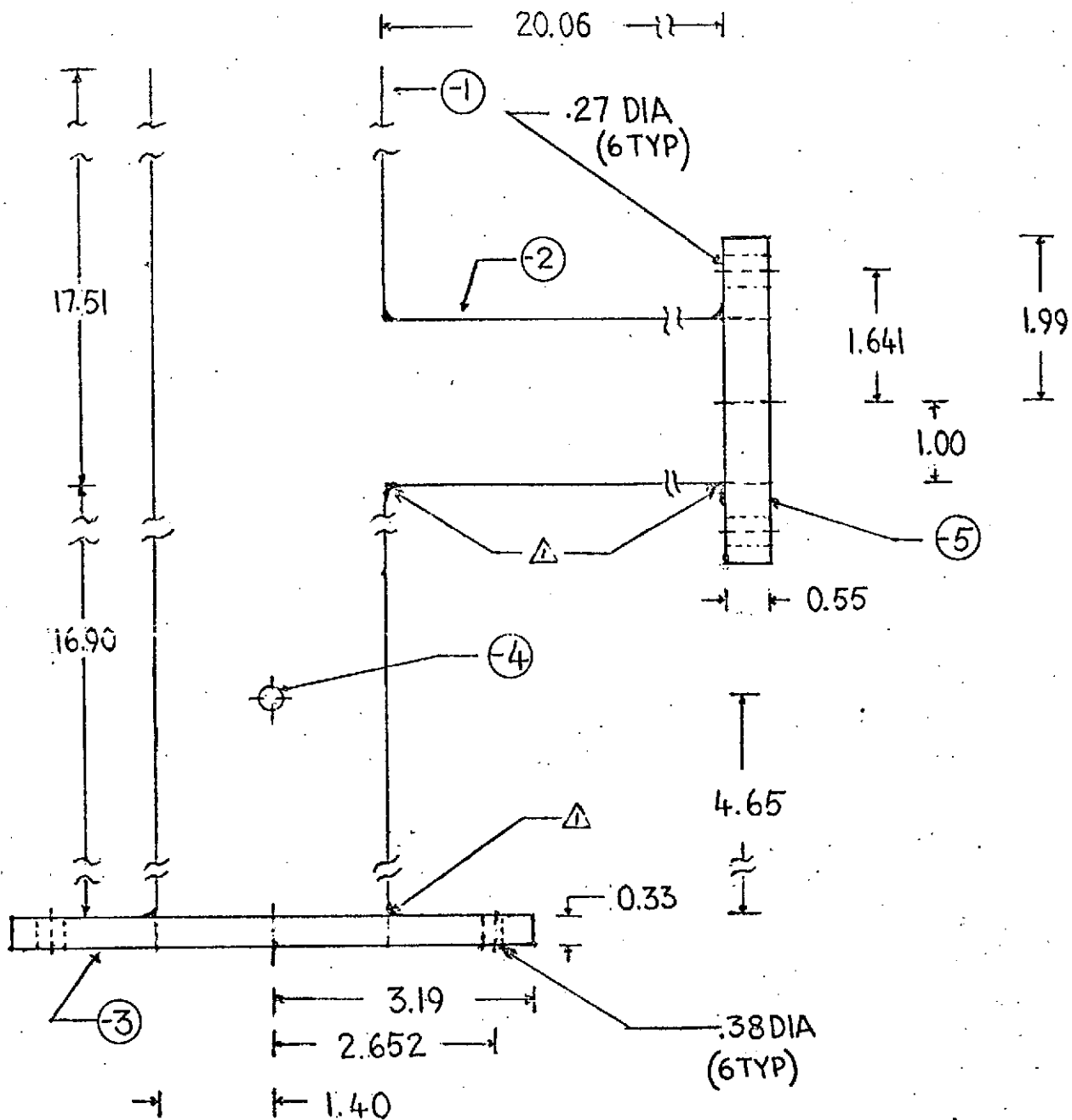
RUPTURE DISC ASSY



BILL OF MATERIALS:

PART N ^o	REQ/ASSY	MATERIAL	STOCK SIZE
-1	1	S.S. WOVEN WIRE FABRIC	0.050 (NOMINAL) THK
-2	1	HONEYCOMB CORE PH 15-7MO WELDED	3/4 THK X 1/4 CELLS X .002 FOIL (ROHR)
-3	1	FOIL, ALUM	A.R. FOR 20 PSIA RUPTURE
-4	2	VITON 'O' RING	2-346-77-545 (PARKER)
-5	1	ALUM	6.38 DIA X .96 THK. SHT.

FIGURE 13
VENT TUBE
P/N 14200



BILL OF MATERIALS:

PART N ^o .	REQ/ASSY	MATERIAL	STOCK SIZE
-1	1	T-304 TUBING	3.0"OD X .083W X 34.74L
-2	1	S.S. BELLOWS WITH WIRE OVERWRAP	2.0"OD X 20.6"
-3	1	S.S. FLANGE	3.190D X 1.40ID X 0.33W
-4	1	S.S. STUB (NPT. LAST .44")	1.93L X .480D X .07W
-5	1	S.S. FLANGE	1.990D X 1.00ID X 0.55W

FIGURE 14

- UPWARD FLAMMABILITY TEST FIXTURE ASSY -

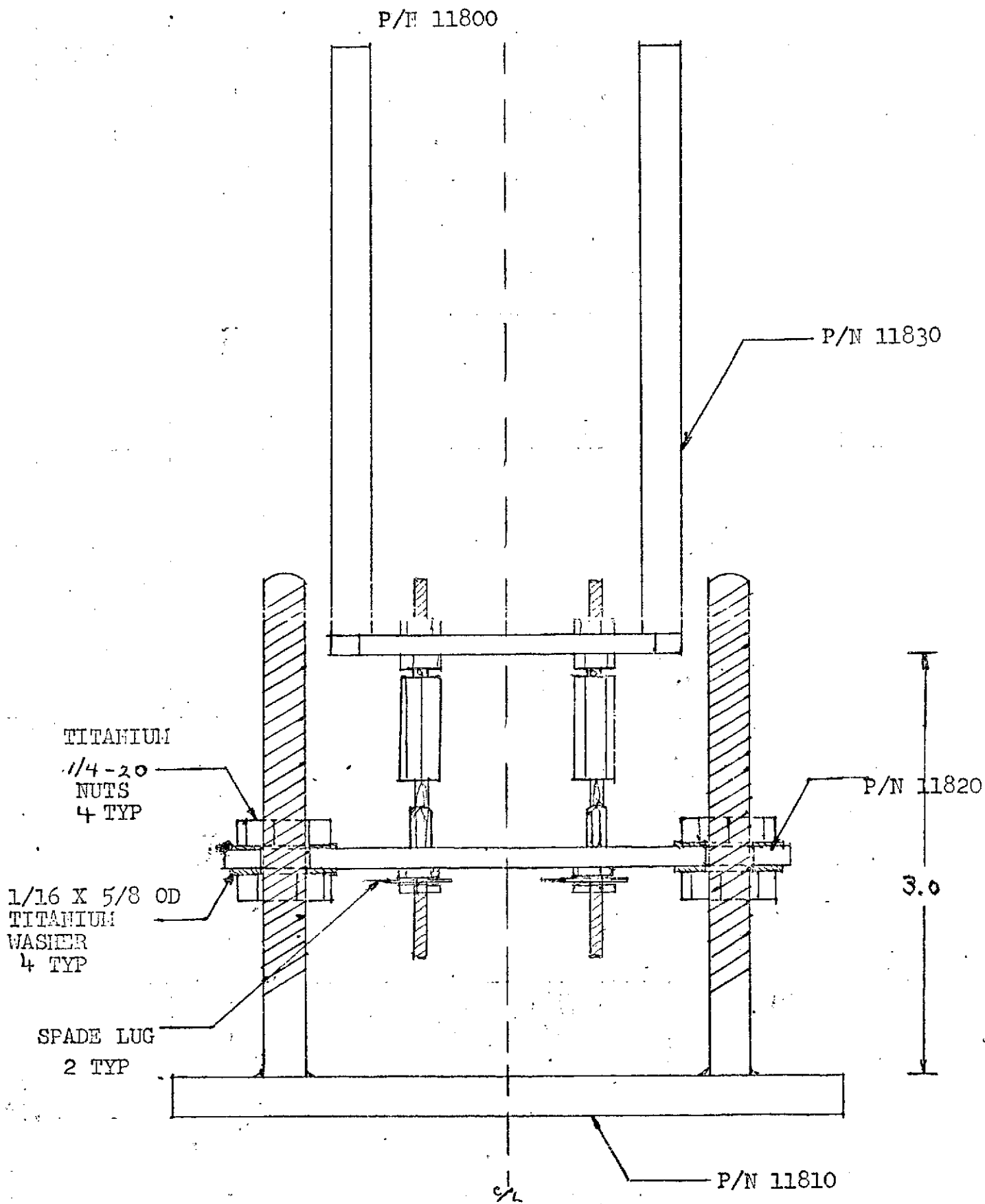
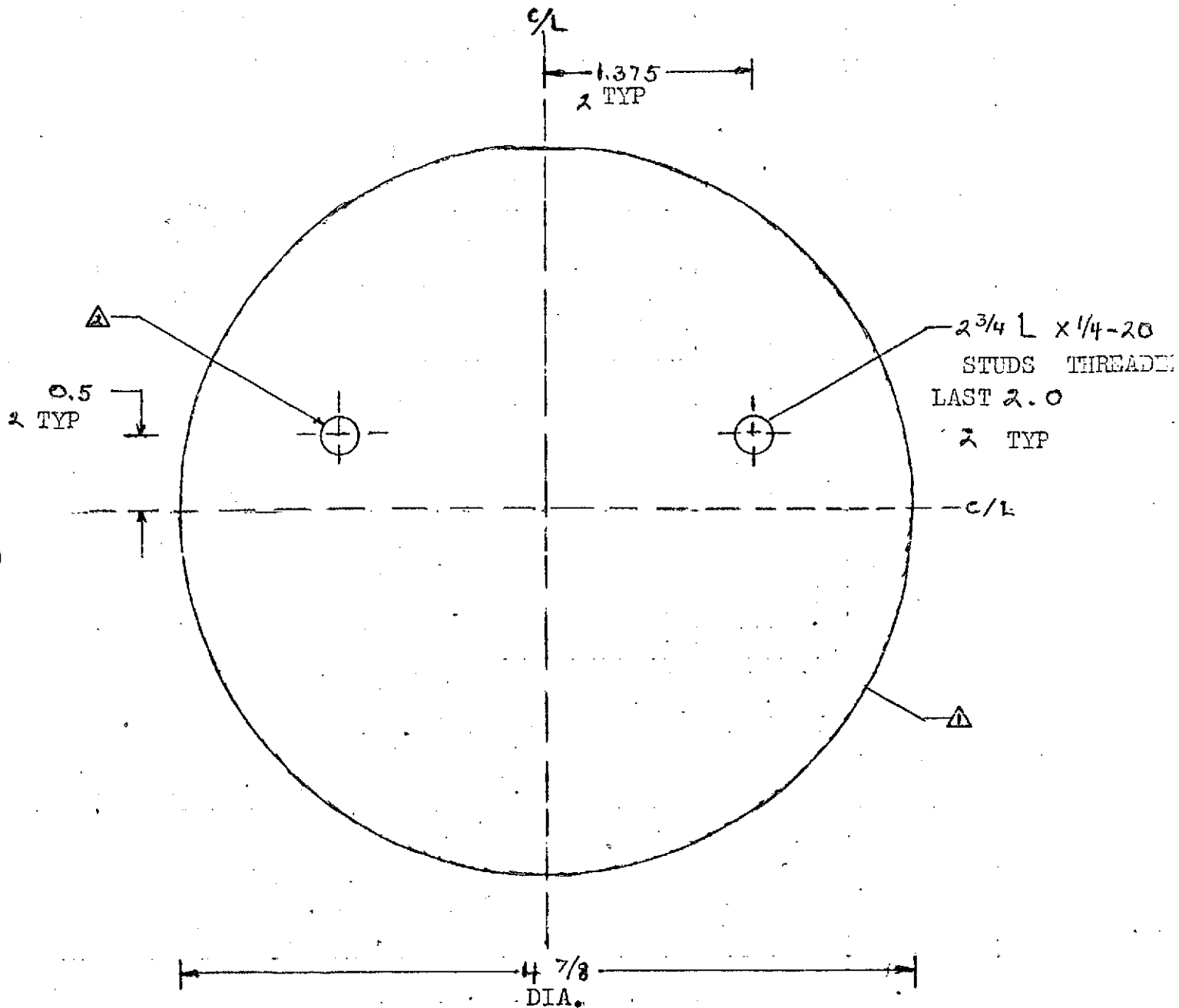


FIGURE 15
 - WINDOW BASE PLATE -
 P/N 11810

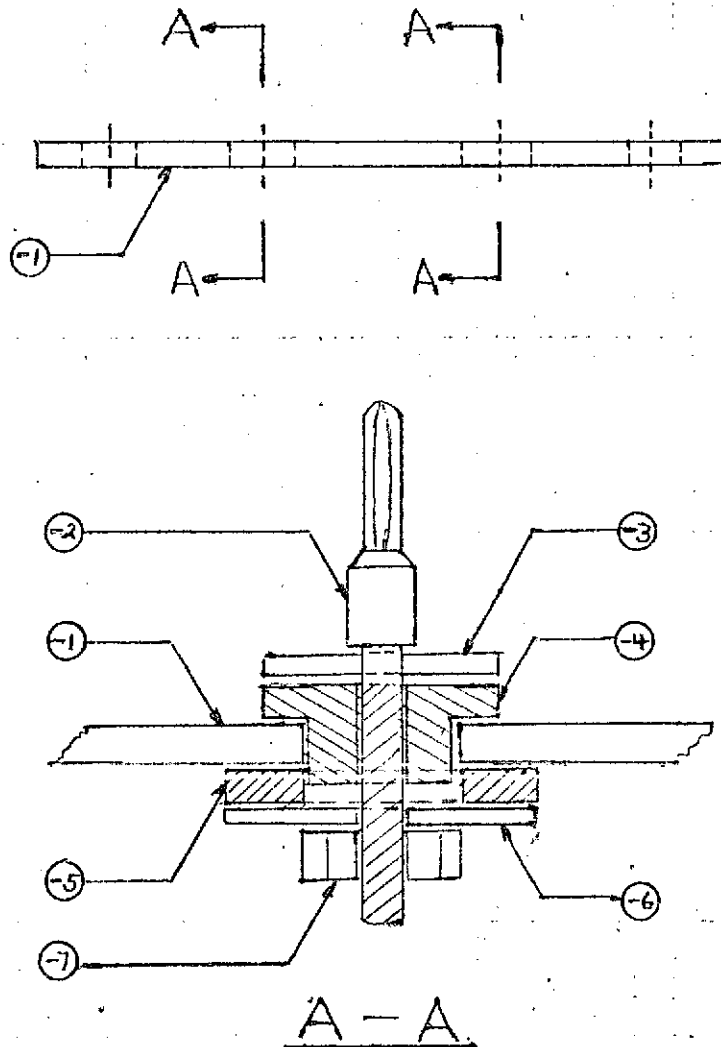


△ FABRICATE FROM 3/16 STAINLESS STEEL.

△ WELD STUDS PERPENDICULAR TO BASE.

FIGURE 16
- POWER BASE PLATE ASSY -

P/N 11820

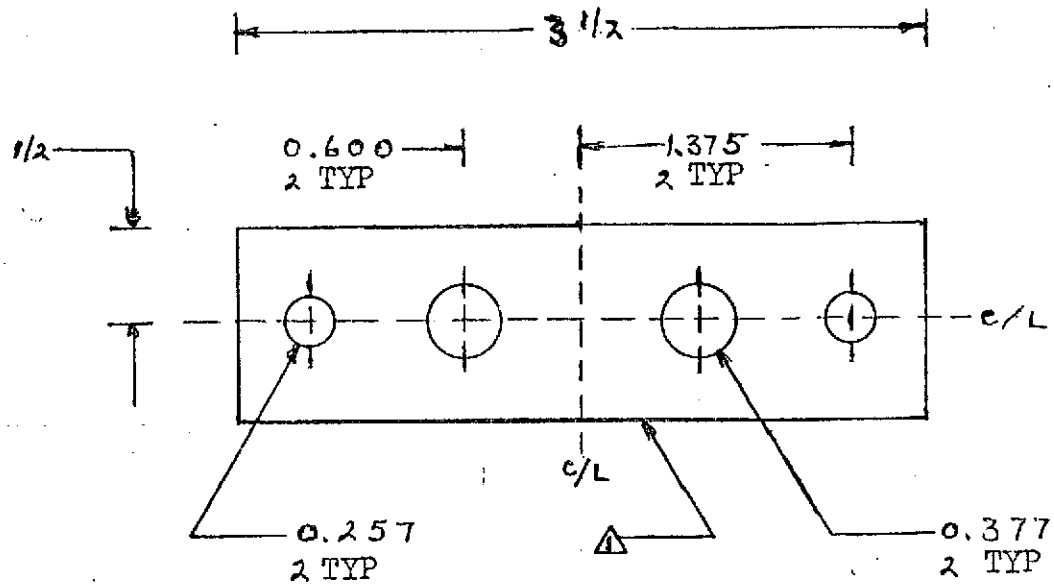


BILL OF MATERIALS

<u>PART NO.</u>	<u>REQ./ASSY</u>	<u>MATERIAL</u>	<u>STOCK SIZE</u>
-1	1	P/N 11821	-
-2	2	BANANA PLUG	P/N 413 (H.H. SMITH)
-3	2	S.S. WASHER	1/32 X 1/2 OD
-4	2	P/N 11840-1	-
-5	2	P/N 11850	-
-6	2	S.S. WASHER	1/32 X 0.60 OD
-7	2	S.S. NUT	8/32

FIGURE 17
- POWER BASE PLATE -

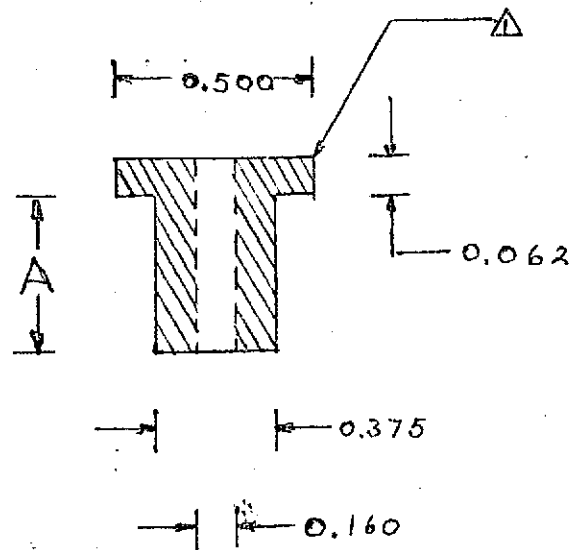
P/N 11821



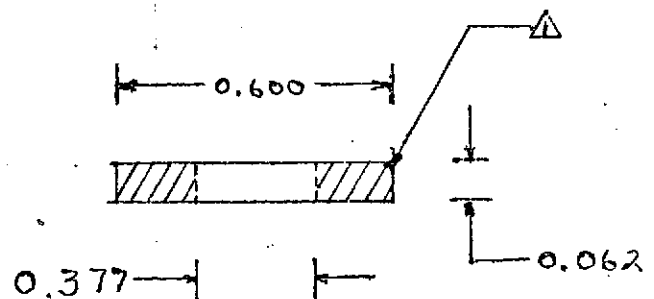
Δ FABRICATE FROM 0.125 STAINLESS STEEL.

FIGURE 18

<u>P/N</u>	<u>TITLE</u>	<u>A</u>
11840-1	SHOULDER WASHER	0.156
11840-2	" "	0.131



11850 BUSHING

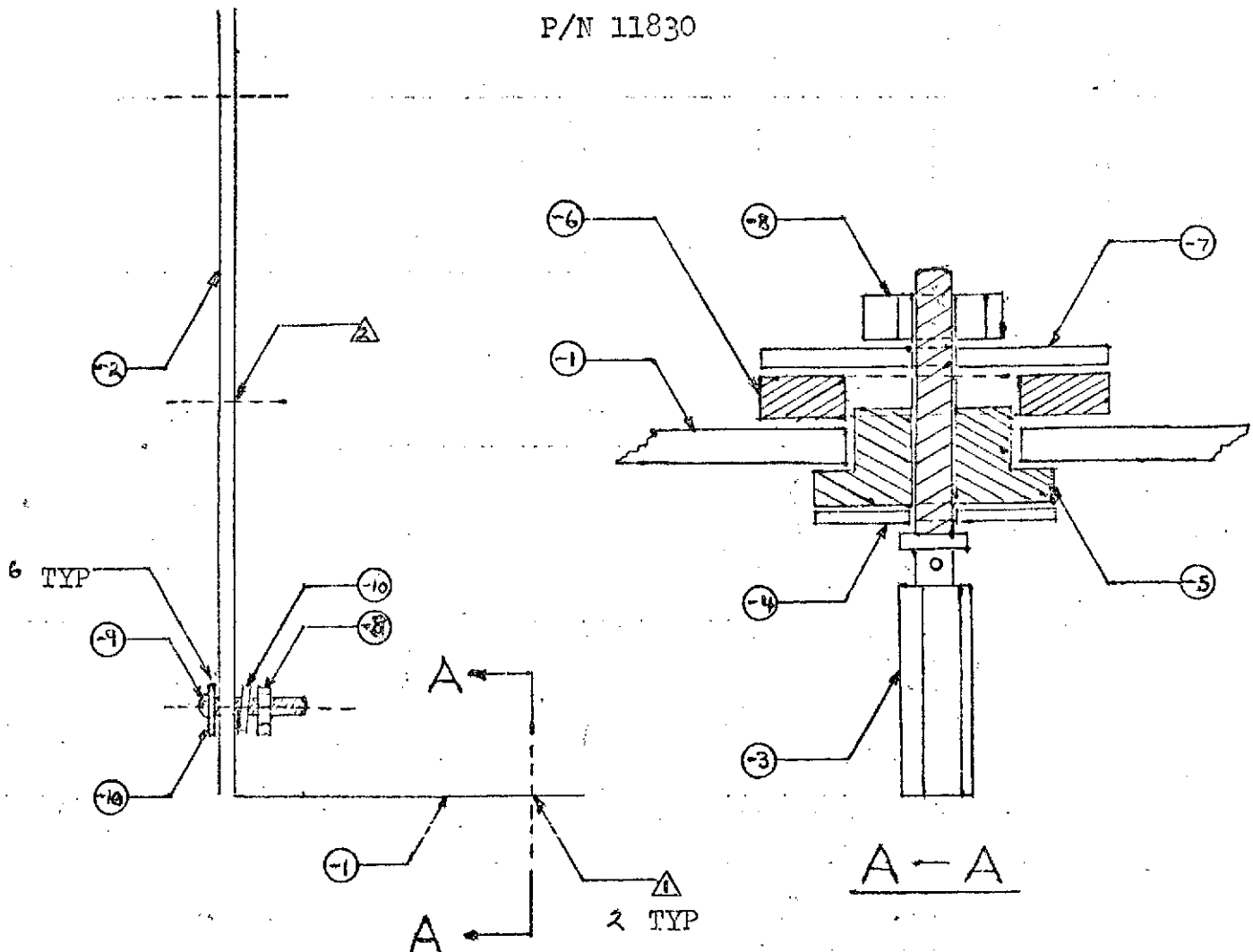


△ FABRICATE FROM TEFLON TFE ROD.

FIGURE 19

- UPWARD FLAMMABILITY TEST SPECIMEN HOLDER ASSY -

P/N 11830



NOTE:

△ ASSEMBLE -3 TO P/N 11831 AS SHOWN.

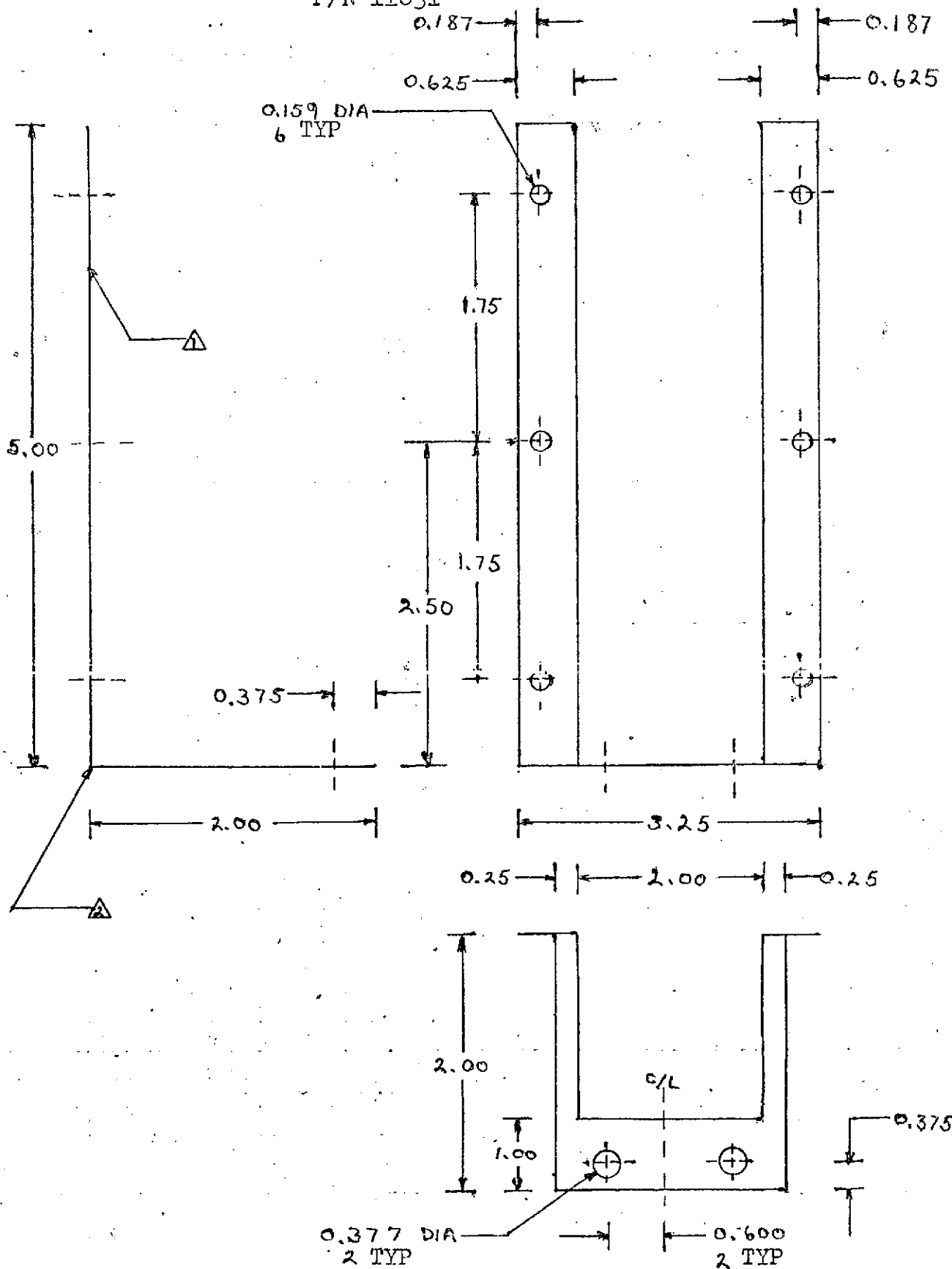
△ ASSEMBLE P/N 11832 TO P/N 11831 AS SHOWN.

BILL OF MATERIALS

PART NO.	REQ./ASSY	MATERIAL	STOCK SIZE
-1	1	P/N 11831	-
-2	2	P/N 11832	-
-3	2	BINDING POST	P/N 137 (H.H. SMITH)
-4	2	S.S. WASHER	1/32 X 1/2 OD
-5	2	P/N 11840-2	-
-6	2	P/N 11850	-
-7	2	S.S. WASHER	1/32 X 0.60 OD
-8	8	S.S. NUT	8-32
-9	6	S.S. BOLT	8-32 X 1/2
-10	12	S.S. WASHER	1/32 X 3/8 OD

- UPWARD FLAMMABILITY TEST SPECIMEN HOLDER -

P/N 11831



△ FABRICATE FROM 0.090 STAINLESS STEEL.

△ 90° SHARP BEND.

- UPWARD FLAMMABILITY TEST SPECIMEN CLAMPING PLATE -

0.159 DIA
3 TYP

0.625

1.75

1.75

2.50

5.00

0.187

E.-25

SLI
7-2-72

- APPENDIX F -

LABORATORY CHECKOUT & OPERATIONAL PROCEDURE

ELECTRICAL POTTING AND COATINGS UPWARD
PROPAGATION FLAMMABILITY TEST

TM 9-11068-1

DATE 1 Aug. 1972

PAGE 1 OF 7

GAS TYPE	PRESSURE (psia)	
	PARTIAL	TOTAL
Oxygen	3.0	10.0
Nitrogen	7.0	

PREPARED BY: S. L. Lieberman

APPROVED BY: W. J. Dewar

FURANE Q C: R. Zoppina

- GENERAL SAFETY PRECAUTIONS -

ALL PERSONNEL MUST WEAR SAFETY GLASSES OR GOGGLES
AND FACE SHIELDS WHILE IN IMMEDIATE VICINITY OF TEST
CHAMBER DURING TESTING OR PRESSURIZED CHECK OUT.

-WARNING-

SMOKING, MATCHES, OR OPEN FLAMES ARE NOT PERMITTED
IN THE IMMEDIATE TESTING AREA.

- References:
1. Furane Drawing No. 10010 C, "NASA/Furane Flammability Test Facility ".
 2. Furane Form 9-11068-2, "Flammability Test Conditions/ Results ".
 3. NHB 8060.1, "Flammability, Odor, And Offgassing Requirements And Test Procedures For Materials In Environments That Support Combustion," Nov. 1971 Edition.

- 1.0 EQUIPMENT CHECKOUT (Delete if already carried out within preceeding 4 hours.) (Reference 1).
- 1.1 Close valves V-3 through -14, inclusive, and turn switches SW-1 and SW-2 to OFF (down).
- 1.2 Turn on power at main fuse box in laboratory.
- 1.3 Open vent valve V-9.
- 1.4 Turn vacuum pump switch SW-1 to ON (up).
- 1.5 Fully open gage vacuum valve V-8.
- 1.6 When a constant reading is observed on gage G-7, close valve V-8.
- 1.7 Turn switch SW-1 to OFF (down).
- 1.8 After five minutes, gage G-7 shall not have lost more than 0.1 psia vacuum (1 gage div. = 0.025 psia). Testing shall not proceed until any leakage greater than 0.1 psia/5 min. is reduced to less than or equal to this allowable limit.
- 1.9 Close valve V-9.
- 1.10 Turn switch SW-1 to ON (up).
- 1.11 Fully open vacuum pump line valve V-12.
- 1.12 When a constant reading is observed on gage G-7, close valve V-12.
- 1.13 Turn switch SW-1 to OFF (down).
- 1.14 After five minutes, gage G-7 shall not have lost more than 0.1 psia vacuum. Testing shall not proceed until any leakage greater than 0.1 psia/5 min. is reduced to less than or equal to this allowable limit.

- 1.15 Open nitrogen cylinder valve V-11.
- 1.16 Nitrogen cylinder gage G-2 shall indicate not less than 100 psi.
- 1.17 Set nitrogen gage G-4 to read 10 ± 0.1 psi by adjusting the center screw on the nitrogen high pressure regulator V-2.
- 1.18 Set gage G-6 to read 2 ± 0.1 psi by adjusting the nitrogen low pressure regulator V-4.
- 1.19 Open vacuum isolation valve V-7.
- 1.20 Slowly open nitrogen low pressure valve V-6.
- 1.21 When the reading on gage G-7 is constant, adjust the pressure to 16.500 ± 0.025 psia with regulator V-4.
- 1.22 Close valve V-7.
- 1.23 After five minutes, gage G-7 shall not have lost more than 0.1 psia pressure. Testing shall not proceed until any leakage greater than 0.1 psia/5 min. is reduced to less than or equal to this allowable limit.
- 1.24 Close valve V-4 so that gage G-6 reads zero.
- 1.25 Close valve V-6.
- 1.26 Close valve V-11.
- 1.27 Open valve V-9.

2.0 TEST

NOTE: UNLESS OTHERWISE STATED,
ALL TEST DATA IS RECORDED
ON FORM 9-11068-2 (Reference 2).

- 2.1 Record gage G-7 pressure on "Vacuum on case" line of Form 9-11068-2.
- 2.2 Prepare test specimen from cured material in accordance with Test No. 1 of Reference 3, except that the specimen shall be 5.0 inches long.
- 2.3 Prepare a silicone ignitor in accordance with Paragraph 4.e, Test No. 1 of Reference 1.
- 2.4 Prepare the test specimen assembly.

- 2.4.1 Clean the Upward Flammability Test Specimen Holder Assembly (Ref. P/N 11830) so that no contaminating organic materials are present.
- 2.4.2 Place the test specimen in the holder so that the specimen is centered between the clamping plates on the sides, and its bottom edge is contiguous with the bottom edge of the clamping plates.
- 2.4.3 Wrap a 10.25 inch length of No. 20 gage bare Nichrome V (80% nickel, 20% chromium) wire so that the center section of the wire is a 6-8 turn helical coil, and its ends are sufficiently long enough to fit into the binding posts (Ref. P/N 11830-3) of the Specimen Holder Assembly while the coil is 0.25 ± 0.03 inches immediately below the bottom edge of the sample.
- 2.4.4 Insert the silicone ignitor into the helix so that the ignitor is retained within the helix by only contact with the wire.
- 2.4.5 Attach the ignitor's wire ends to the binding posts on the holder so that the helix is 0.25 ± 0.03 inches immediately below, and at the midpoints of, the bottom edge of the sample.
- 2.5 Open the loading port and insert the Test Specimen Assembly so that the specimen is closest to the view port (Ref. P/N 11300).
- 2.6 Carefully but firmly seat the Test Specimen Assembly's binding post to the banana plugs of the Power Base Plate Assembly (Ref: P/N 11820).
- 2.7 Remove hand from chamber without disturbing the specimen and close the loading port.
- 2.8 Close valve V-9.
- 2.9 Turn switch SW-1 to ON (up).
- 2.10 Fully open valve V-12.
- 2.11 When a constant reading is observed on gage G-7, close valve V-12.
- 2.12 Turn switch SW-1 to OFF (down). Record pressure reading on gage G-7 on Form 9-11068-2 in the box under the word "vac".
- 2.13 Open valve V-11.
- 2.14 Gage G-4 should read 10 ± 0.1 psi. Adjust center screw of regulator V-2 until such reading is obtained.

- 2.15 Open oxygen cylinder valve V-10.
- 2.16 Oxygen cylinder gage G-1 shall indicate not less than 100 psi.
- 2.17 Set oxygen gage G-3 to read 5 ± 0.1 psi by adjusting the center screw on the oxygen high pressure regulator V-1.
- 2.18 Set oxygen gage G-5 to read 2 ± 0.1 psi by adjusting the oxygen low pressure regulator V-3.
- 2.19 Open valve V-7.
- 2.20 Add 3.00 psia oxygen to the reading recorded in step 2.12 by bleeding oxygen with oxygen line pressure valve V-5, into system so that gage G-7 indicates this total pressure. Record this pressure on form in top box of "Test Setting" (with "O₂" in top box and "N₂" in bottom box, under "GAS" notation).
- 2.21 Close valve V-5.
- 2.22 Close valve V-7.
- 2.23 Repeat steps 2.19 through 2.22 inclusive, until gage G-7 remains within ± 0.1 psia of required test setting for five minutes. If pressure exceeds the limit value, determine cause of leak, repair as necessary, and repeat entire procedure to this point.

NOTE: VENT AND NITROGEN FLUSH
CHAMBER BEFORE CARRYING
OUT REPAIRS.

- 2.24 Turn regulator V-3 counterclockwise until gage G-5 reads zero.
- 2.25 Set nitrogen gage G-6 to read $2. \pm 0.1$ psi by adjusting regulator V-4.
- 2.26 Open valve V-7.
- 2.27 Add 7.00 psia nitrogen to reading recorded in step 2.20 by bleeding nitrogen into system with valve V-6 so that gage G-7 indicates this total pressure. Record this total pressure on form in bottom box of "Test Setting."
- 2.28 Close valve V-6.
- 2.29 Close valve V-7.

- 2.30 Repeat steps 2.26 through 2.29 inclusive, until gage G-7 remains within ± 0.1 psia of required test setting for five minutes. If pressure exceeds the limit value, determine cause of leak, repair as necessary, and repeat entire procedure to this point.

NOTE: VENT AND NITROGEN FLUSH
CHAMBER BEFORE CARRYING
OUT REPAIRS.

- 2.31 Turn regulator V-4 counterclockwise until gage G-6 indicates zero.
- 2.32 Soak specimen three minutes.
- 2.33 Turn power supply switch SW-2 to ON (up) and adjust the current on gage G-8 to $55. \pm 2.5$ amperes. If ignition or considerable degradation is not obtained in one minute, increase the current by 5 amperes (i.e. from 55. to 60., 60. to 65., etc.) until such time as the wire fails or ignition occurs, but for no less than 30^{+20}_{-10} seconds. If the wire fails, maintain the voltage to the wires until it is positively established that current does not flow by bridging insulation gaps.

WARNING: DO NOT TOUCH POWER
SUPPLY TERMINALS OR
LEADS DURING THE
REMAINDER OF THE TEST.

- 2.34 Observe the test and record data specified on Test Form 9-11068-2.
- 2.35 When visible specimen degradation no longer occurs, record the time and turn switch SW-2 to OFF (down).
- 2.36 Adjust regulator V-4 to 2 ± 0.1 psi on gage G-6.
- 2.37 Open valve V-7.
- 2.38 Fully open valve V-6 slowly until ambient pressure is reached.
- 2.39 Open valve V-9.

WARNING: TEFLON INSULATION IS
USED NEAR EVERY TEST FOR
NAS 9-11068. PURGE THE
CHAMBER FOR NOT LESS
THAN THREE MINUTES.

- 2.40 After three minutes close valve V-9.
- 2.41 Close valve V-7.
- 2.42 Close valve V-6.
- 2.43 Adjust regulator V-4 until gage G-6 reads zero.
- 2.44 Turn switch SW-1 to ON (up).
- 2.45 Fully open valve V-12.
- 2.46 When a constant reading is observed on gage G-7, close valve V-12.
- 2.47 Turn switch SW-1 to OFF (down).

NOTE: OPEN VALVE V-9 SLOW
ENOUGH TO PREVENT
JERKING MOTION OF
GAGE G-7 NEEDLE.

- 2.48 Fully open valve V-9.
- 2.49 Open loading port. Observe and record condition of specimen.
- 2.50 Carefully remove the Test Specimen Holder Assembly from the chamber.
- 2.51 Close the loading port.
- 2.52 Close valve V-9.
- 2.53 Close valves V-10 and V-11.
- 2.54 Turn off power at main fuse box in laboratory.

APPENDIX

- G -

FLAMMABILITY

TEST CONDITIONS/RESULTS

DATA SHEET

FLAMMABILITY TEST CONDITIONS/RESULTS

Specimen No.: _____ Date: _____ Test Engr.: _____

SPECIMEN

1. Length: _____ inch

2. Thickness: max.: _____ inch min.: _____ inch ave.: _____ inch

TEST CONDITIONS

1. Pressure: Gate G-7 (1) (W&T) - Vacuum on case: _____ psia

- Atmos.: _____ psia (source: _____)

- Chamber (psia)

Gas	Vac.	test setting	actual
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

2. Voltage: _____ volts

Current: _____ amps

3. Comments: _____

TEST RESULTS

1. Pressure (chamber): peak: _____ psia max.: _____ psia

final: _____ psia final: _____ psia

2. Burn time: start flame-out glow-out

t = _____ secs.

Δ = _____ secs.

3. Observations:

3.1 flame: color: _____ nature: _____

3.2 smoke/soot: none some profuse

color: _____ nature: _____

3.3 general: Yes No

sparking: ☐ ☐

sputtering: ☐ ☐

dripping flaming particles: ☐ ☐

4. Comments: _____

5. Specimen Post-Test Appearance

5.1 Maintained General Configuration: Yes No

5.2 Residue in Original Configuration: _____ %

5.3 Melted: Yes No

5.4 Color; Exterior: _____

Interior: _____

5.5 Texture; Powdery: Yes No

Crusty: Yes No

6. Comments: _____

CONCLUSIONS

☐ Noncombustible

☐ Self-extinguishing in _____ inches, in _____ minutes

☐ Non self-extinguishing in _____ minutes (total burn time)

Comments: _____

A P P E N D I X

- H -

DETERMINATION OF ORGANIC OFFGASSING PRODUCTS AND CARBON MONOXIDE (1)

- (1) Test No.6 of MSC-D-NA-0002, "Procedures and Requirements for the Flammability and Offgassing Evaluation of Manned Spacecraft Non-metallic Materials."

TEST NO. 6
DETERMINATION OF ORGANIC OFFGASSING PRODUCTS
AND CARBON MONOXIDE

NOTE: This test will not be conducted prior to applicable flammability tests nor will it be conducted on materials which have failed a flammability test unless specifically requested.

1.0 PURPOSE

This procedure establishes the criteria for a screening test, which will determine the suitability of nonmetallic materials for use in the space vehicle crew compartment environments. The criteria is established with respect to production by out-gassing of potentially toxic or objectionable volatiles. The volatiles are separated into two categories: Carbon Monoxide and Total Organics.

2.0 TEST CONDITIONS - PRESSURES & ATMOSPHERE

The test pressure and gas mixture conditions for the pertinent materials category shall be designated by the requirements for each program.

3.0 CRITERIA OF ACCEPTABILITY

- 3.1** The reporting laboratories shall report total organics as micrograms per gram ($\mu\text{g/g}$) of sample material using methane as a standard.
- 3.2** The maximum allowable level of total organics in the tested configuration shall not exceed 100 micrograms of total organics per gram of sample.
- 3.3** Carbon monoxide shall be reported as the number of micrograms produced by one gram of sample material.

- 3.4 The maximum allowable level of carbon monoxide in the tested configuration shall not exceed 25 micrograms of carbon monoxide per gram of sample.

4.0 TEST DISCIPLINE

- 4.1 Each test shall be directed by the cognizant test engineer or his appointed alternate.
- 4.2 Approval of the test shall be indicated at the end of the test procedure by the signatures of the responsible test engineer. Entries transcribed to the test data sheets will be also verified by the test engineer.

5.0 TEST EQUIPMENT

- 5.1 **Test Chamber** - The test chamber shall have a minimum main chamber volume of two liters. It shall have a configuration and be fabricated of materials which allow ready cleaning. A thermometer or thermocouple and pressure gauge for temperature and pressure determination, respectively, shall be included in the test chamber. The chamber shall be connected to a manifold system to permit evacuation, pressure readings, gas introduction, and sample withdrawal. An alternate system would be to connect the chamber directly to a gas chromatograph and/or mass spectrometer for the gas analyses.
- 5.2 **Heating Source** - The oven shall maintain constant temperature control over the test chamber to $\pm 5^{\circ}\text{F}$. The temperature during sample exposures shall be recorded.
- 5.3 **Vacuum Pump** - The vacuum pump shall be capable of producing a vacuum less than one Torr.
- 5.4 **Analytical Equipment** - The analytical equipment shall consist of the following types of equipment and any other instruments which the tester desires to use efficiently to evaluate offgassing products.

- 5.4.1 Gas Chromatograph System - Recorder, thermal conductivity and hydrogen flame ionization detectors. The columns shall have the capability of separating light organic and inorganic gases, organic sulfides and mercaptans, halogenated hydrocarbons, representative aliphatic and aromatic hydrocarbons including aldehydes, ketones, alcohols, and esters. The hydrogen flame ionization detector has greater sensitivity to organic materials. Conversely, because of the flame ionization detector's lack of sensitivity to the inorganic compounds listed above, the thermal conductivity detector is used for their identification.
- 5.4.2 Recording Infrared Spectrophotometer capable of analyzing 3 microliters (3 μ l) or less of liquid with accessories which include an infrared gas cell with 10m path length.
- 5.4.3 Mass Spectrometer
- 5.4.4 Electron Capture Detector
- 5.4.5 Trapping System suitable for trapping and transfer of microliter quantities of liquid from the gas chromatograph to the infrared spectrophotometer or mass spectrometer. A direct G. C. mass spectrometer connection can replace the trapping system if desired.
- 5.4.6 Gas Sampling System suitable for transfer of measured volumes of gas samples from the test chamber to the gas chromatograph.
- 5.4.7 Calibration Gas Samples as required to quantify detector sensitivity and readout. These may be bought from a manufacturer or made up in the laboratory.

6.0 PREPARATION OF TEST EQUIPMENT

- 6.1 Prior to loading of sample into a container, the container shall be loaded to test pressure with test atmosphere, heated at $155^{\circ} \pm 5^{\circ} \text{ F}$ for 24 hours, and the gas analyzed for total organics and carbon monoxide. The container shall be certified clean for use if the total organics value is 5 ppm by volume methane or less over the test atmosphere and the carbon monoxide value is 5 ppm by volume or less. After use, the container shall be reused without cleaning if the sample values are equal to or less than the above. If not, the container shall be heated and purged with air or nitrogen by some convenient method such as a heat gun with blower, loaded to test pressure with test atmosphere, and tested to the above specifications.
- 6.2 Leak Check - The test system shall not increase in pressure more than one Torr. while remaining at a reduced pressure of one Torr for a time period of one hour.

7.0 PRETEST PROCEDURE

7.1 Verify material identification as one of the following:

7.1.1 Manufacturer's certification

7.1.2 NASA certification

7.1.3 Contractor certification

7.1.4 Definite identification not available

8.0 TEST SPECIMENS

8.1 All the materials tested in the program shall be classified into four categories; surface, volume, weight, or specialized items.

8.2 Samples based on Surface

This classification is defined as all those materials that are essentially two-dimensional. This would include films, fabrics, coatings, finishes, inks, primers, adhesives, thin film lubricants, tapes, and electrical insulating material.

The sample tested shall have a surface area of 46.5 ± 2.5 square inches per liter of test container. Coatings, finishings, etc. shall be coated on clean aluminum substrate of 0.020 ± 0.01 inch thickness. Material thickness, curing process, and method of application shall be in accordance with the manufacturer's recommendations. Material may be coated on both sides of the aluminum panel. Tapes and other similar materials with an adhesive surface shall be fastened to a similar aluminum panel. In all cases, only the outer surface of a material on the aluminum panel is counted in the surface area determinations. Films, fabrics, and similar materials shall be cut to give 46.5 ± 2.5 square inches surface area. Since these materials are two-surfaced in use, both the top and bottom surface shall be counted in determining total surface area. Heat shrinkable tubing shall be applied and shrunk to simulate actual use configuration.

8.3 Samples based on Volume

This classification is defined as all those materials having an indefinite volume but having a large real surface area due to surface convolutions or matting. These shall include foams and other blown or foamed materials and insulation padding.

Samples of these materials shall be cut to a thickness of 0.50 ± 0.05 inches unless the existing thickness is less than 0.40 inches. In this case, the existing thickness shall be used. The material shall be cut to such a size as to give $7.75 \pm .75$ square inches of total surface per liter of test container volume. All surface, tops, bottoms, and sides shall be used to compute total surface area. In cases where the natural thickness is such that the material cut would be too large to be placed into the container, two or more pieces may be cut as long as the total surface area requirement is met.

8.4 Samples based on Weight

This classification is defined as all those materials having a definite bulk and not falling into the volume classification. This shall include potting compounds, molding compounds, cast or formed objects, solid wires, and thick plastics. Liquids that are not used or applied as coatings or thin films shall be included.

The samples shall be used as much as possible in the supplied configuration and cut to give 5.0 ± 0.25 grams per liter of test container. Potted or molded materials shall be prepared and cured per manufacturer's directions and cut to weight. Liquids shall be placed in an aluminum dish 2.25 ± 0.25 inches in diameter. Sample weight shall be 5.0 ± 0.25 grams per liter.

8.5 Specialized Items

It must be recognized that some materials will not meet the above classifications and must be specially handled. This will most often occur with non-homogeneous materials. These cases will be tested in the manner designated by the Test Engineer. The manner of testing and sample preparation shall be fully reported.

9.0 PROCEDURE

- 9.1** Purge the test chamber until the minimum test atmosphere concentration is 95 percent and begin heating. Bring the chamber to $155^\circ \pm 5^\circ\text{F}$ and adjust the chamber pressure to test pressure.
- 9.2** After twenty-four hours, check the test gas for contaminants with the gas chromatograph. Proceed to 9.3 if the total contamination is less than 5.0 ppm by volume over the test atmosphere. If the contamination exceeds the above value, the test chamber shall be flushed and rechecked after an additional twenty-four hours. This procedure shall be continued until the contamination is below the specific level of 5 ppm. If the gassing contamination continues indefinitely, revision of the test chamber is indicated.

9.3 Place a clean weighed specimen prepared per Section 8.0 in the test chamber.

9.3.1 The chamber shall be evacuated through a liquid nitrogen trap to below one Torr. The chamber shall then be closed off and the test gas, filtered through a 5X Molecular Sieve, bled into the chamber to test pressure. The conditions of exposure are held at $155 \pm 5^\circ \text{F}$ for a total period of 72 hours. Following the designated exposure period, the chamber is brought to room temperature. After the final gas samples are taken, the test specimen is removed from the chamber and weighed. The gases are then analyzed for the following:

9.3.1.1 Total organics expressed as methane equivalents.

9.3.1.2 Outgassing components exceeding $10 \mu\text{g/g}$ including but not limited to the following: HCN, Benzene, Xylene, MEK, Chloroform, n-Butanol, Dichloromethane, 1-4 Dioxane, Formaldehyde, Trichloroethylene, HCL, Ammonia, Hydrogen Fluoride, Carbonyl Fluoride and Silicon Tetrafluoride. Condensates in the cold trap may be recovered as gas and likewise analyzed and plotted.

9.3.1.3 Quantity of carbon monoxide evolved.

9.4 Determination of Total Organics - The gas chromatograph with the proper columns, Beckman Total Hydrocarbon Analyzer or an equivalent instrument may be used for the determination.

9.5 Outgassing components, including those listed in 9.3.1.2, that exceed $10 \mu\text{g/g}$ shall be identified and recorded in the reporting format.

9.6 Determination of Carbon Monoxide - The carbon monoxide content of the evolved gases shall be determined under Section 9.4 above by utilizing an appropriate separation and analytical technique having the sensitivity to detect within $0.5 \mu\text{g/g CO}$.

9.7 All charts and data are to be retained in the event further identification or evaluation is necessary.

10.0

REPORTING DATA

10.1 The following test data and pertinent information concerning the material tested shall be reported:

10.1.1 Name and positive identification of the material (paragraph 7.2)

- 10.1.2 Vendor designation and vendor
- 10.1.3 Usage, and surface area in the spacecraft
- 10.1.4 Weight and size - length, width and thickness of sample tested
- 10.1.5 Test pressure and atmosphere
- 10.1.6 Results of tests
 - 10.1.6.1 Carbon monoxide in micrograms per gram
 - 10.1.6.2 Total organics in micrograms per gram
 - 10.1.6.3 Identity of organics greater than 10 micrograms/gm
 - 10.1.6.4 Weight loss, percent.
- 10.1.7 Name and number of test procedure
- 10.1.8 Date of test
- 10.1.9 Test number
- 10.1.10 Identity of the testing agency
- 10.1.11 Name and signature of test coordinator.

APPENDIX

- 1 -

ODOR

TEST

1. Test No. 6 of NHB 8060.1, "Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments That Support Combustion," NASA Office of Manned Space Flight, Nov. 1971 Edition.

406 TEST NO. 6 - ODOR TEST

1. PURPOSE

The purpose of this test is to determine the odor characteristics of materials. A material that fails these requirements shall not be used.

Note: The results of Test No. 7 should be reviewed before conducting this test so that members of the odor team are not inadvertently exposed to toxic offgassing products.

2. ODOR TEST REQUIREMENTS AND CRITERIA

a. Selection of Test Panel for Odor Evaluation. The test conductor shall establish a pool of qualified personnel.

- (1) Members of the pool shall be male and each member shall be capable of detecting seven basic odors from the following solutions:

<u>Primary Odor</u>	<u>Standard Compound</u>	<u>Amount Dilution in Water</u>
Ethereal	1,2 - Dichlorethane	0.4 ml in 500 ml
Camphoraceous	1,8 - Cineole	5 μ l in 500 ml
Musky	15- hydroxypenta- decanoic acid lactone	1 mg in 1,000 ml
Floral	1 - methyl - 1 - ethyl - 2 phenyl propanol - 1	0.075 ml in 500 ml
Minty	methone (dl)	2 μ l in 333 ml
Pungent	formic acid	25 ml of 90 percent solution in 500 ml
Putrid (methyl methyl dithiomethane disulphide)		1 μ l in 10,000 ml

- (2) Members of the pool shall be given three odorless solution along with the seven primary standards for detection of odor.
- (3) The solutions shall be freshly prepared once a month or as needed and stored in closed amber bottles away from heat sources and direct sunlight.
- (4) The established pool for odor evaluation shall be requalified every three months.
- (5) A panel of at least five members shall be selected from the pool for odor evaluations.
- (6) Odor panel members should receive a nose and throat examination by a medical staff member before and after each odor test session.
- (7) Members of the pool shall not participate on the panel if their sense of smell is affected in any manner such as by recent smoking, ingestion of highly flavored foods, and exposure to pungent vapors.
- (8) At least one of the seven basic odors shall be presented to the panel members as a standard for sensing odor before evaluation of odors from any sample material.
- (9) Panel members shall not be permitted to see the material or to know the gas sample being evaluated for odor, nor to see the ratings of the other panelists.
- (10) Odor evaluation on sample materials shall be performed in a suitable room actively ventilated and free from extraneous odors.
- (11) Odor evaluations shall be performed on every new bottle of oxygen or gas used for the tests.
- (12) Provisions shall be made for flushing the face mask of residual odors.

- b. Odor Evaluations. If the odor is offensive to one person, the material shall be disqualified.

3. TEST CONDITIONS - PRESSURES AND ATMOSPHERE

- a. The test pressure and gas atmosphere conditions for the pertinent materials category shall be designated by the requirements for each program.
- b. The atmosphere and pressure in the test chamber at the start of exposure shall be that specified for each program.

- c. The sample materials shall be heated at test temperature of $155 \pm 5^{\circ}\text{F}$. for a test duration of at least 72 hours.
- d. Leak Check. The test system shall not increase in pressure more than 0.1 psia while remaining at a reduced pressure of 0.1 psia for a time period of one hour after isolation from the pump.
- e. Odor evaluations shall be started within three hours of the conclusions of the thermal treatment.
- f. All measuring equipment shall have the proper calibration stickers.
- g. All equipment shall be cleaned in accordance with commonly accepted laboratory practices and shall be given a distilled water rinse and oven dried at a minimum temperature of 200°F . The equipment shall be free of extraneous odors before each use.

4. TEST EQUIPMENT

- a. Test Chamber. The test chamber shall be made of Pyrex glass and its internal volume shall be two liters minimum. The test chamber shall have the following:
 - (1) A gas tight removable cover
 - (2) A sampling valve
 - (3) A sampling port capable of being sealed with a septum. A laboratory vacuum dessicator may be used as a test chamber.
- b. Oven. The oven shall be capable of providing a constant interior temperature from $70 \pm 2^{\circ}\text{F}$ up to $200 \pm 5^{\circ}\text{F}$.
- c. Test Gas Supply. The test gas shall be commercially available and conform to the appropriate specifications. Suitable equipment for transferring gas to the test chamber shall be used.
- d. Sample Transfer Equipment. Glass syringes, of 3 cc minimum capacity, shall be used for measuring and transferring sample atmospheres from the test chambers to the panel member's face mask.
- e. Pressure Gage. The pressure gage shall be capable of measuring absolute pressures to within 0.1 psia accuracy.
- f. Olfactometer. The olfactometer shall consist of a mask made of odorless flexible material which can be applied to a panel member's face.

- g. Odor Testing Equipment. All odor testing equipment shall be nonproducers of odor and carbon monoxide, as set forth under the test conditions in paragraph 406.3.

5. TEST SPECIMENS PREPARATION

- a. Categories. All the materials tests shall be classified into four categories; surface, volume, weight, or specialized items.

- b. Samples Based on Surface. This classification is defined as all those materials that are essentially two dimensional. This would include films, fabrics, coating, finishes, inks, primers, adhesives, thin film lubricants, tapes, and electrical insulating material.

- (1) The sample tested shall have a surface area of 300 ± 16 square centimeters (46.5 ± 2.5 square inches) per liter of test container. Coatings, finishings, etc., shall be coated on clean aluminum substrate of 0.50 ± 0.1 millimeters (0.020 ± 0.001 inch) thickness. Material thickness, curing process, and method of application shall be in accordance with the manufacturer's recommendations. Material may be coated on both sides of the aluminum panel. Tapes and other similar materials with an adhesive surface shall be fastened to a similar aluminum panel. In all cases, only the outer surfaces of a material on the aluminum panel is counted in the surface area determinations. Films, fabrics, and, similar materials shall be cut to give 300 ± 16 square centimeters (46.5 ± 2.5 square inches) surface. Because these materials are two surfaced in use, both the top and bottom surface shall be counted in determining total surface area. Heat shrinkable tubing shall be applied and shrunk to simulate actual use configuration.

- c. Samples Based on Volume.

- (1) This classification is defined as all those materials having a definite volume but having a large real surface area due to surface convolutions or matting. These shall include foams and other blown or foamed materials and insulation padding.
- (2) Samples of these materials shall be cut to a thickness of 1.27 ± 0.10 centimeters (0.50 ± 0.05 inch) unless the existing thickness is less than 1.2 centimeters (0.50 inch). In this case, the existing thickness shall be used. The material shall be cut to such a size as to give 50 ± 5 square centimeters (7.75 ± 0.75 square inches) of total surface per liter of test container volume. All surfaces, tops, bottoms, and sides shall be used to compute total surface area. In cases where the natural thickness is such that the material cut would be too large to be placed into the container, two

or more pieces may be cut as long as the total surfaces area requirement is met.

d. Samples Based on Weight

- (1) This classification is defined as all those materials having a definite bulk and not falling into the volume classification. This shall include potting compounds, molding compounds, cast or formed objects, solid wires, and thick plastics. Liquids that are not used or applied as coatings or thin films shall be included.
- (2) The samples shall be used as much as possible in the supplied configuration and cut to give 5.0 ± 0.25 grams per liter of test container. Potted or molded materials shall be prepared and cured per manufacturer's directions and cut to weight. Liquids shall be placed in suitable nonreactive dishes 5.7 ± 0.5 centimeters (2.25 ± 0.25 inches) in diameter. Sample weight shall be 5.0 ± 0.25 grams per liter of test container.

e. Specialized Items.

It must be recognized that some materials will not meet the above classifications and must be specially handled. This will most often occur with nonhomogeneous materials. These cases will be tested in the manner designated by the Test Engineer in charge. The manner of testing and sample preparation shall be fully reported.

6. PRETEST PROCEDURE

- a. Note that the material has been identified through one of the items below:
 - (1) Manufacturer's certification.
 - (2) NASA certification.
- b. Before these tests, candidate materials must have been tested for total organics and carbon monoxide and must meet the criteria of acceptability.

7. TEST PROCEDURE

The procedure shall be conducted in the following order:

- a. Sample materials shall be prepared according to the conditions outlined under sample preparation in paragraph 406.5.
- b. After placing the sample material in the test chamber, the chamber shall be evacuated to 0.1 psia or less. The test chamber shall then be pressurized to test pressure and test atmosphere.

- c. The test chamber shall be exposed to a temperature of 155 \pm 5°F in an oven for a time period of at least 72 hours, allowing time for initial warm-up.
- d. Following the isothermal exposure, the test chamber shall be removed from the oven and allowed to return to room temperature.
- e. The pressure in the test chamber shall be measured and recorded after return to room temperature.
- f. Observation of distillable residues on interior chamber walls shall be made and recorded.
- g. The test chamber shall be pressurized to one atmosphere with test gas and a sampling septum installed.
- h. Odor Test. Known volumes of sample atmosphere shall be extracted from the test chamber by means of a syringe and diluted with fresh gas in the following proportions:
 - (1) One part of sample atmosphere to 29 parts of test gas
 - (2) One part of sample atmosphere to 9 parts of test gas
 - (3) No dilution, or as drawn from the flask
 - (4) Testing shall begin with the greatest dilution and progress toward no dilution. A material that fails at a high dilution shall not be tested in the more concentrated dilution.

8. REPORTING.

Test data shall be reported in accordance with instructions contained in paragraph 208 on a form similar to Figure 2-1. The following test data and pertinent information concerning the materials shall be reported:

- a. Name and positive identification (paragraph 406.6) of material.
- b. Vendor designation and vendor.
- c. Total rating numbers determined by the panel members.
- d. Definition of the odor as interpreted by each panel member.
- e. Status of the material as a result of the test.
- f. Name and number of the test procedures.
- g. Test pressure, atmosphere, and temperature.
- h. Data of test.

i. Identify of the testing agency.

j. Name and signature of test coordinator.

APPENDIX

- J -

SP-R-0022
December 12, 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

SPECIFICATION
VACUUM STABILITY REQUIREMENTS OF POLYMERIC
MATERIAL FOR SPACECRAFT APPLICATION

DESIGNED BY:

Jimmy M. Gray
J. M. Gray, Chief
Thermodynamics and Materials Branch

APPROVED BY:

Owen Maynard
Owen Maynard, Chief
Systems Engineering Division

APPROVED BY:

James A. McDevitt
James A. McDevitt
Colonel, USAF
Manager
Apollo Spacecraft Program

TABLE of CONTENTS

<u>PARAGRAPH</u>	<u>PAGE</u>
1. Purpose	1
2. Scope	1
3. Requirements	1
4. Selection and Verification	1
5. Implementation	2
6. Quality Assurance Provisions	2
7. Test Procedures	3
7.1 Purpose	3
7.2 Test Conditions	3
7.3 Test Discipline	4
7.4 Criteria of Acceptability	4
7.5 Test Equipment	4
7.6 Sample Preparation	5
7.7 Pre-test Procedure	6
7.8 Test Procedure	7
7.9 Reporting	8

1.0 PURPOSE

The purpose of this document is to establish requirements and test guidelines for polymeric material used in space thermal/vacuum atmosphere around sensitive optical equipment.

2.0 REQUIREMENTS

The control and verification of material and assembly outgassing to the guidelines of this document are based on the following requirements:

a. The polymeric materials used in the thermal/vacuum atmosphere shall not contaminate the optical equipment in that assembly.

b. The polymeric materials used in any application shall not affect the optic system at any adjacent equipment.

The materials shall have a maximum weight loss of 1.0 percent and a volatile condensable material (VCM) content of 0.1 percent when tested in accordance with the test procedure in paragraph 7.

3.0 SCOPE

The scope of this document covers the control of polymeric materials used near or adjacent to optical equipment that are exposed to the thermal vacuum atmosphere of space. This document establishes the requirements and defines the test method to evaluate polymeric materials used in the vicinity of optical surfaces in space applications. This document should not be used for evaluation of material applications inside the pressurized area of a spacecraft or materials used inside any hermetically sealed container.

4.0 SELECTION AND VERIFICATION REQUIREMENTS

Use of polymeric material near optical equipment shall be restricted to those materials which have a maximum volatile condensable material (VCM) of 0.1

percent and a total weight loss of 1.0 percent when tested in accordance with the test method described in paragraph 7. NASA/MSC SED (Systems Engineering Division) will provide the contractor a list of approved materials for use in vacuum atmosphere, upon request. NASA/MSC/SED also maintains a complete file of all material tested.

The use of materials that have been tested but failed the requirements of this specification may be used if the contractor can provide rationale for its use that is approved by NASA/MSC/SED. The following are examples of some considerations for use as rationale for a material that has failed the VCM and weight loss requirements:

- a. The material is the best available for the particular application.
- b. The quantity and surface area of the material is small, and not in the immediate vicinity of an optic system.
- c. The material may be vacuum cured for additional time.

5.0 IMPLEMENTATION

The contractor shall provide for NASA/MSC/SED approval, a list of all polymeric materials selected for use around optical equipment or in the same defined compartment as optical equipment. The following information is required:

- a. Manufacturer's trade name
- b. Manufacturer of the material
- c. Volatility condensable material (VCM test data)
- d. Rationale for use of material that failed the requirements of paragraph 4.0.

6.0 QUALITY ASSURANCE REQUIREMENTS

The Quality Assurance requirements for the test in paragraph 7 are as follows:

- 6.1 All instrumentation utilized in this test shall be in current calibration and shall bear appropriate documentation to this effect from an approved calibration laboratory.
- 6.2 All materials tested shall have tracability equivalent to that required for materials used in the construction of flight hardware.
- 6.3 Test laboratories involved in testing to the requirements of this document shall be certified as to competency by conducting tests of standard materials under step-by-step Quality Assurance surveillance. Such certification shall be required yearly.
- 6.4 Upon completion of tests, test engineers shall certify that all required procedures were followed and that the results reported are correct.
- 6.5 At random intervals (not to exceed three months) Quality Assurance shall observe selected portions of all procedures to verify routine conformance to test procedures.
- 6.6 Daily surveillance, or step-by-step Quality Assurance sign-off on procedures, is not required.

7.0 TEST PROCEDURE

7.1 Purpose

The purpose of this test is to measure weight loss and volatile condensable materials (VCM) content of polymeric materials under controlled laboratory conditions.

7.2 Test Conditions

The test on polymeric materials shall be conducted under the following conditions:

Pressure	10^{-6} TORR or Less
Temperature of specimen	$125^{\circ}\text{C} \pm 1^{\circ}\text{C}$
Temperature of condensible plates	$25^{\circ}\text{C} \pm 1^{\circ}\text{C}$
Vacuum exposure time	24 hours

7.3 Test Discipline

7.3.1 Each test shall be directed by the cognizant test engineer or his appointed alternate.

7.3.2 The cognizant test engineer shall affix his signature to all test data sheets and verify adequacy of identification information.

7.4 Criteria of Acceptability

The materials shall have a volatile condensible material (VCM) content of less than 0.1 percent by weight. The total weight loss of the material shall not exceed 1.0 percent by weight.

7.5 Test Equipment

The test equipment shall consist of the following:

7.5.1 A vacuum system capable of maintaining 10^{-6} TORR for a period of 24 hours.

7.5.2 Sample holder made of stainless steel crucibles (see figure 1). The sample holder shall be nominally 1 1/2 inches long and 1/2 inch in diameter.

7.5.3 Collector plate (see figure 2) shall be made of copper. The collector plate shall be 1 1/2 inches in diameter.

7.5.4 The test apparatus shall be made of copper. The apparatus shall be such that at least four sample holders and collector plates can be accommodated at one time. The sample section

shall be capable of maintaining the samples at 125°C and maintaining the collector plates at 25°C. The test equipment shall be constructed in the general manner described in Figure 3, which is a section down the middle of the apparatus. Figure 3A shows a cross section of the apparatus of a sample holder. Figure 3B shows a typical arrangement of the standoff's used for the heating chamber and the baffles. The baffle construction is shown in Figure 4.

7.5.5 A balance that is capable of weighing one (1) micro gram.

7.6 Sample Preparation

7.6.1 Materials to be tested shall be prepared in 100 to 200 milligram sample sizes and placed in stainless steel holders after preparation as specified below:

7.6.1.1 Solid Materials: Specimens shall be cut into small pieces having 1/16 maximum dimension. Samples shall be placed in a desiccator after preparation, and remain there until the samples are placed in the test chamber.

7.6.1.2 Coatings: Materials that are normally used as coatings shall be applied to stainless steel screen. Coating procedure shall be specified in the request for test. One-hundred mesh, or finer, screen shall be used.

7.6.1.3 Liquids: Oils and viscous liquids shall be absorbed into Refrasil A-100 batting that is free from any volatile residues.

7.6.2 All material shall be cured or applied in accordance with the manufacturer's procedures or the applicable contractor process specification prior to test.

7.7 Pre-test Procedure

7.7.1 Verify that all test equipment is in current calibration.

7.7.2 Verify material identification by one of the following:

7.7.2.1 Manufacturer's certification

7.7.3.1 NASA certification

7.7.3.3 Contractor certification

7.7.3 Prepare sample in accordance with paragraph 6.0.

7.7.4 The sample holder shall be thoroughly cleaned prior to use.

7.7.5 The collector plates shall be cleaned and polished prior to installation in the apparatus.

7.7.6 Extreme care shall be taken to prevent contamination of specimens or exposed portions of the test apparatus with any organic oils, residue, etc.

7.7.7 Identify each sample in the apparatus.

7.7.8 Each run shall contain one standard sample for calibration purposes. This sample shall be one of known weight loss and VCM.

7.8 Test Procedure

- 7.8.1 Initial Weight Determination: The VCM collector plates, the stainless steel holders used for sample holding and the stainless steel wire screens, and Refrasil A-100 batting used for preparation of coating and liquid material samples shall be preweighed. Samples in the stainless steel holders shall be stored in a desiccator prior to weighing.
- 7.8.2 Samples shall be weighed and recorded and placed in the desiccator until they are placed in the VCM apparatus.
- 7.8.3 The weighed samples shall be placed in the compartments of the heating blocks and the VCM collector plates shall be fastened to the cooling block of the apparatus.
- 7.8.4 The system shall be evacuated and held at a maximum pressure of 10^{-6} TORR.
- 7.8.5 When the unit has reached 10^{-6} TORR, the samples shall be heated to $125^{\circ}\text{C} \pm 1^{\circ}\text{C}$, and maintained for 24 hours. The VCM collector plates shall be maintained at $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$ during the test.
- 7.8.6 At the end of the 24-hour heating period, the heater blocks shall be cooled to 50°C and the vacuum chamber purged with dry nitrogen gas for 10 minutes.
- 7.8.7 The samples in their holders and the VCM collector plates shall be removed from the apparatus and immediately placed in a desiccator.
- 7.8.8 Weigh the samples and the collector plates as soon as possible after removal from the VCM apparatus, and record these weights.

7.8.9 All weights shall be determined to the nearest one (1)
micro gram.

7.9 Reporting

7.9.1 All reports shall contain the following information:

7.9.1.1 Name of material

7.9.1.2 Vendor designation and vendor

7.9.1.3 Cure condition of the sample.

7.9.1.4 VCM content to the nearest 0.01 percent based on
the original weight of the sample

7.9.1.5 Total weight loss to the nearest 0.01 percent based
on the original weight loss of the sample

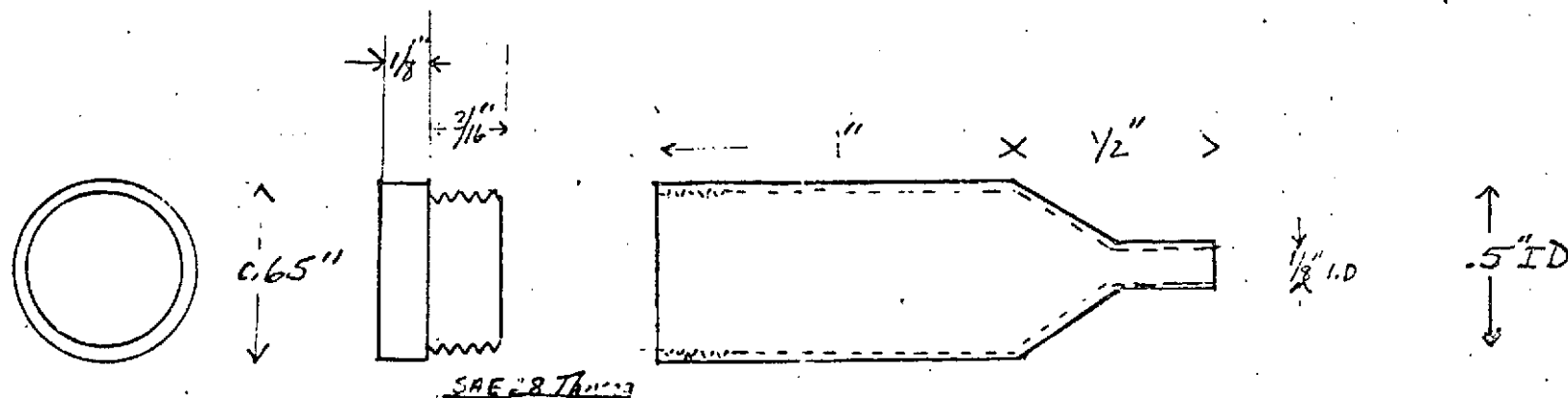
7.9.1.6 Date of test

7.9.1.7 Test number

7.9.1.8 Identity of testing organization

7.9.1.9 Name of test coordinator

7.9.1.10 Name and signature of test engineer

SAMPLE HOLDER CAPSAMPLE HOLDER

Material - Stainless Steel
Tolerances - Nominal

FIGURE I - STAINLESS STEEL SAMPLE HOLDER

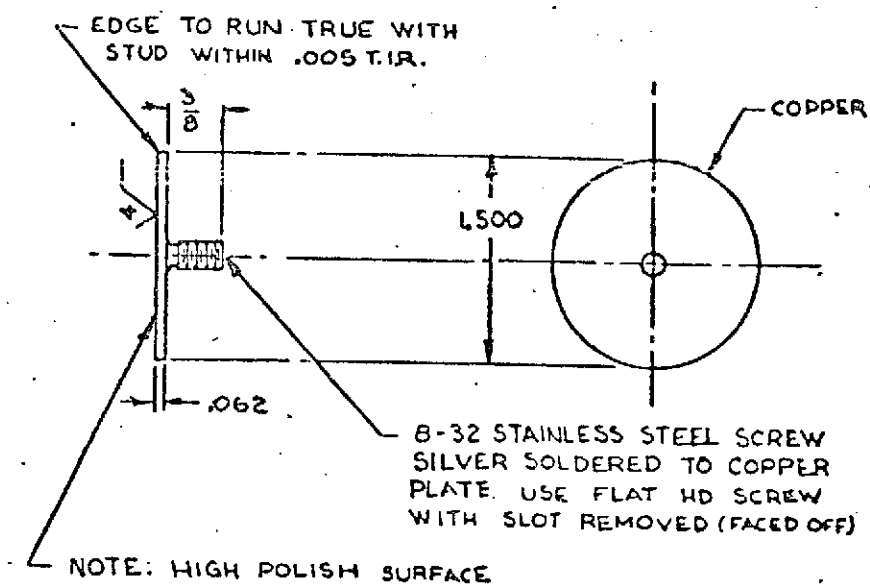


FIGURE 2 Copper Collector Plate

Figures 2 and 3 were extracted from "Polymers for Spacecraft Applications" by R. F. Muraca, et al., Stanford Research Institute.

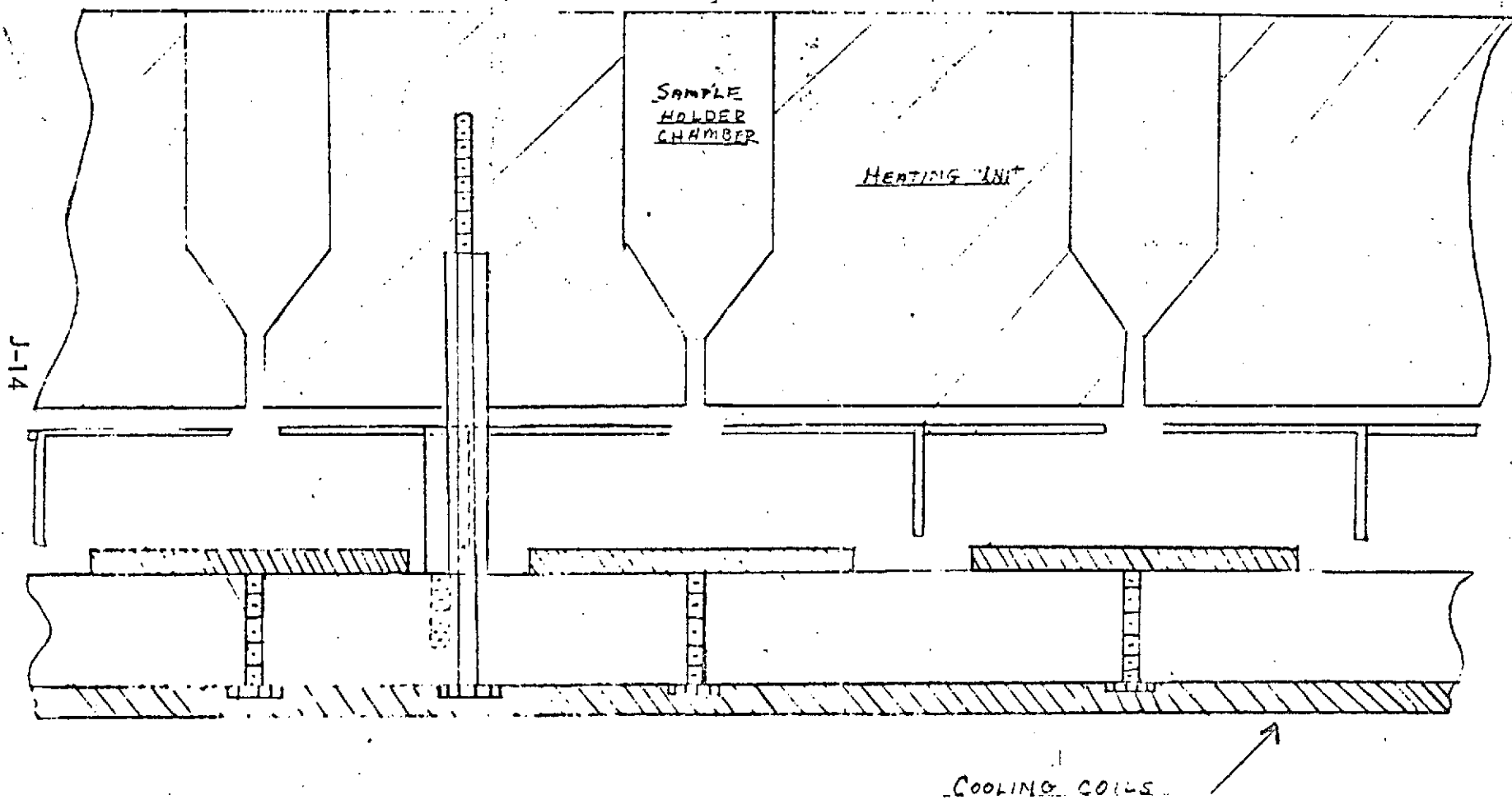


FIGURE 3 - Typical Section of the Assembled Apparatus

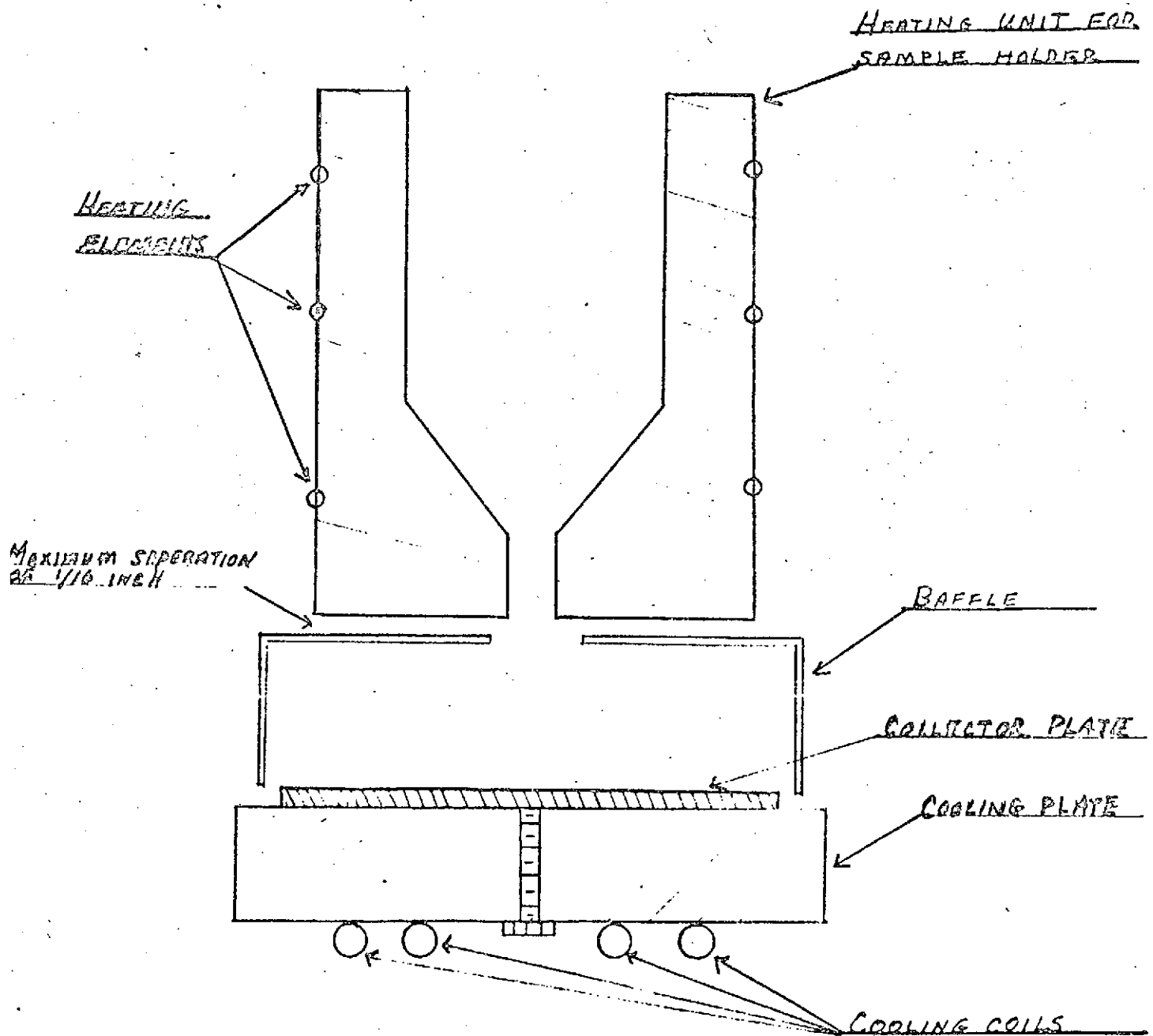


FIGURE 3A - Typical Cross Section of the Apparatus of a Sample Holder

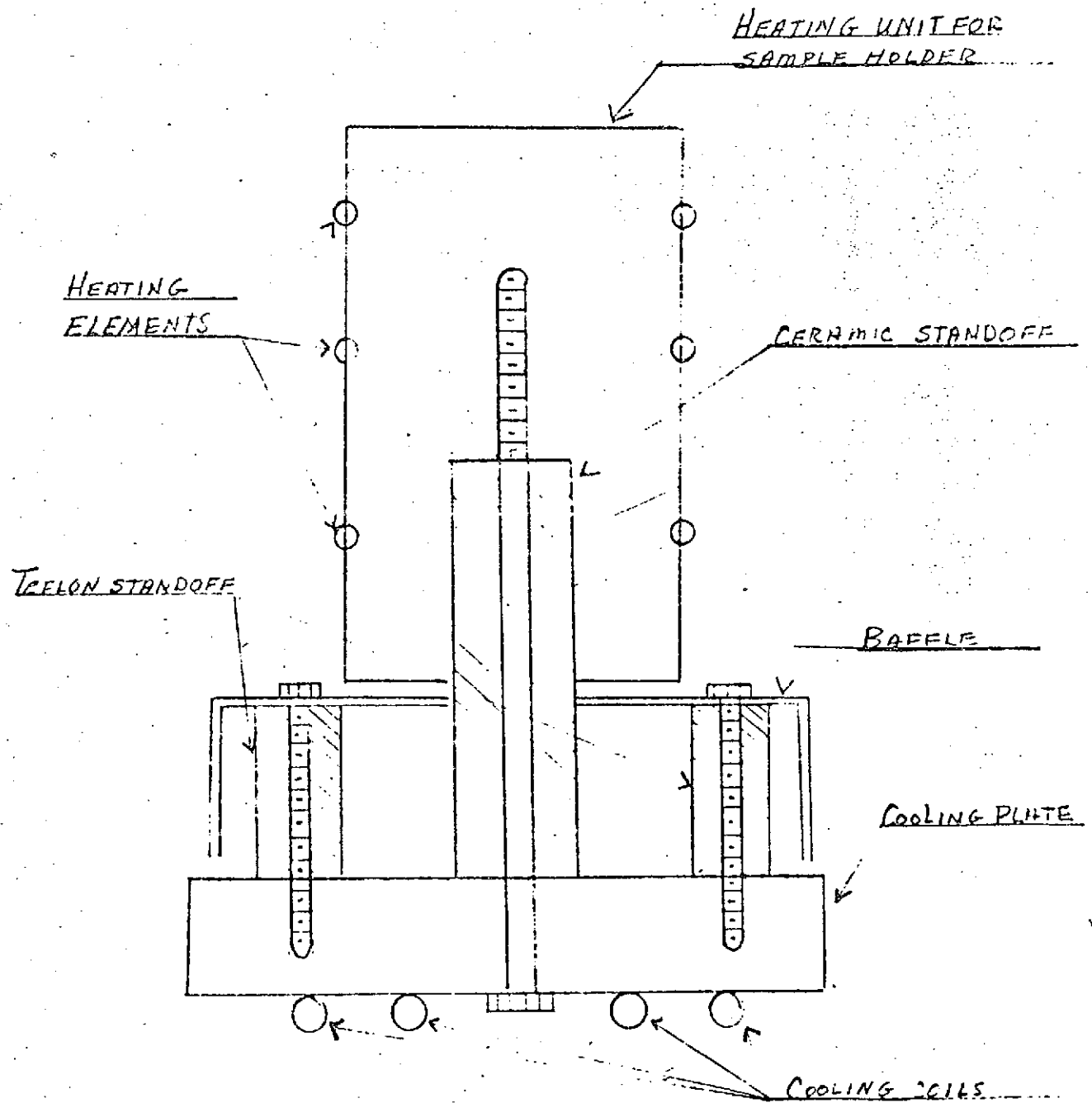
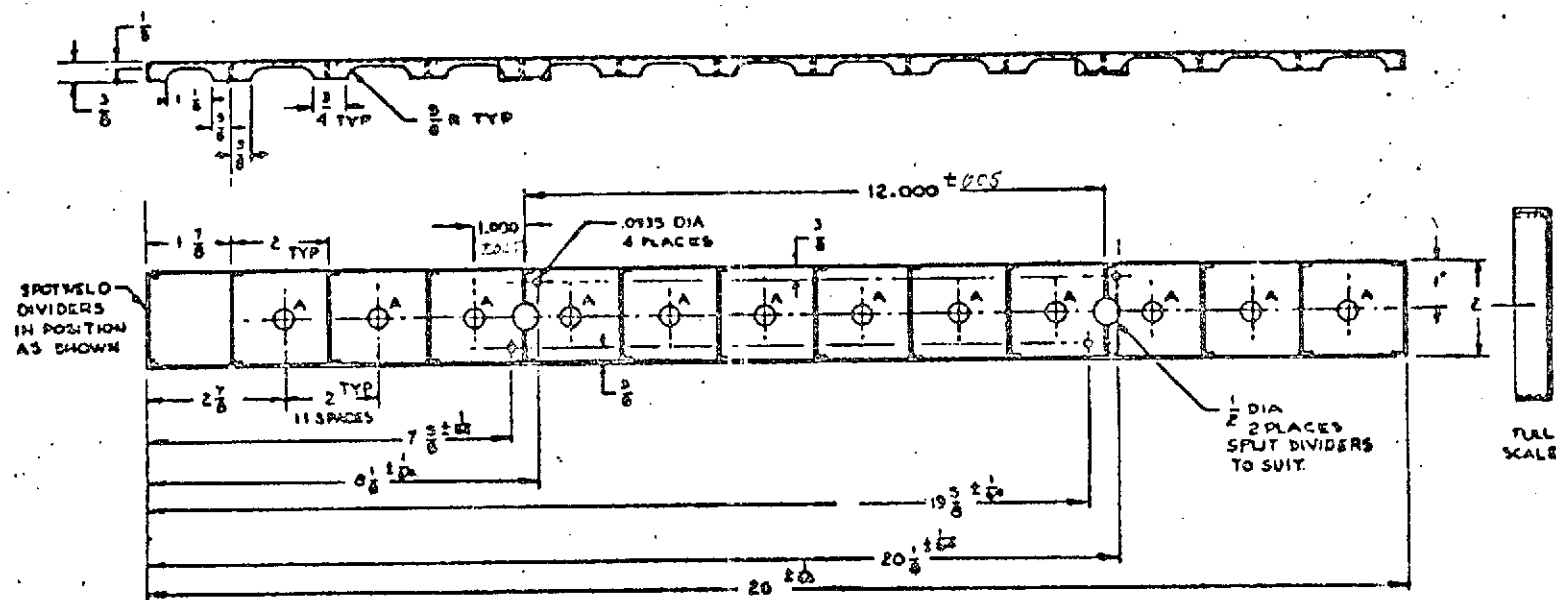


FIGURE 3A - TYPICAL CROSS SECTION AT THE STANDOFF'S OF THE APPARATUS



Material - 1/8" Stainless Steel

Isolator - 1/8" Thick

FIGURE 4 Typical 12 Sample Baffle Plate

APPENDIX

- K -

GOX

PNEUMATIC AND MECHANICAL

IMPACT

TEST GUIDELINES (1)

1. Test No. 10 of MSC-PA-D-67-13, Addendum 2A, "Apollo Spacecraft Nonmetallic Materials Requirements.", NASA Manned Spacecraft Center, Systems Engineering Div., 7 June 1971.

GOX Pneumatic and Mechanical Impact Test Guidelines

1.0

PURPOSE

- 1.1 The purpose of this test is to determine the sensitivity and compatibility of nonmetallic materials and metallics with pure gaseous oxygen (GOX). The test is applicable to materials selected for use in the high pressure oxygen system (Category D).
- 1.2 All Category D materials according to the enclosed test plan, must be subjected to GOX high pressure pneumatic impact screening tests. All Category D materials must also be subjected to mechanical impact conditions in high pressure GOX, unless NASA approves the omission of this test. NASA approval should be obtained by the user identifying the material application, presenting data to show its lack of mechanical impact, and requesting NASA approval for omission of the mechanical impact test.

2.0

TEST CONDITIONS

- 2.1 Only materials that have passed the other tests required of candidates for high pressure oxygen systems (Category D) shall be subjected to Test No. 8. Upon special request, a material which has failed another Category D test may be subjected to Test No. 8.

2.2 Candidate materials shall be tested in 95^{+5}_{-0} percent GOX (MIL-027210D) at the pressures listed below:

2.2.1 The pressure for the pneumatic impact test shall equal the maximum pressure of the intended application multiplied by a factor of 1.33 and rounded to the next higher 500 psia pressure increment* Example: An application pressure of 1100 psia multiplied by a factor of 1.33 equals 1467 psia. The next higher 500 psia increment or 1500 psia would be the screening test pressure.

2.2.2 The pressure for the mechanical impact test shall equal the maximum pressure of the intended application multiplied by a factor of 1.5 and rounded to the next higher 500 psia pressure increment.* Example: An application pressure of 1100 psia multiplied by the factor of 1.5 equals 1650 psia. The next higher 500 psia increment or 2000 psia would be the screening test pressure:

*NOTE: When the intended application pressure

multiplied by the safety factor equals less than 1000 psia, the product is rounded to the next higher 200 psia pressure increment to determine the screening test pressure.

2.3 Standard Test Conditions

2.3.1 Pneumatic Impact

2.3.1.1 Temperature $70 \pm 10^{\circ}\text{F}$.

2.3.1.2 5 cycles over 60 seconds, constitutes one pneumatic impact test.

2.3.1.3 Pneumatic impact - 4 individual tests at the higher acceptable screening test pressure.

2.3.1.4 Test chamber pressurization time, 95% total pressure rise within 20 ± 7 milliseconds.

2.3.2 Mechanical Impact

2.3.2.1 Temperature $70 \pm 10^{\circ}\text{F}$.

2.3.2.2 Mechanical impacts - 4 individual impacts at the highest acceptable screening test pressure.

2.4 Test Equipment

2.4.1 The pneumatic test equipment is shown schematically in Figure 1.

2.4.2 The GOX (Pneumatic) impact test system is illustrated in Figure 2.

2.4.3 Figures 3 and 4 represent diagrammatically the mechanical impact apparatus and test chamber, respectively.

3.0

TEST DISCIPLINE

- 3.1 Each test shall be directed by the cognizant Test Engineer or his appointed alternate.
- 3.2 The cognizant test conductor shall affix his signature to all test data sheets.

4.0

CRITERIA OF ACCEPTABILITY

- 4.1 All Category D materials must be subjected to the pneumatic impact test. In addition, all materials must pass the mechanical impact test unless NASA approves omission of this test. A material is considered to pass a screening test pressure if no reactions occur after four attempts at that pressure. Reaction is distinguished by discoloration, evidence of combustion, and/or detonation.
- 4.2 Pneumatic Test Acceptance Criteria
- Candidate materials (Category D) shall be considered acceptable for GOX pneumatic applications at pressures equal to the acceptable pneumatic screening test pressure divided by 1.33. The acceptable pneumatic screening test pressure is defined as the pressure at which no reaction is noted after four tests at that pressure with five complete pneumatic cycles constituting one test. After each test, a new sample shall be installed.
- 4.3 Mechanical Impact Acceptance Criteria
- Candidate materials (Category D) shall be considered acceptable for

GOX mechanical impact applications at pressures equal to the acceptable pneumatic screening test pressure divided by 1.5. The acceptable mechanical impact screening test pressure is defined as the pressure at which no reaction is noted after four attempts at that pressure, when the sample is mechanically impacted with an energy of 50 ± 3 foot-pounds/inch². After each test, a new sample shall be installed.

5.0

SAMPLE PREPARATION

- 5.1 When the test material is submitted, data shall accompany the material giving the proposed application, the maximum pressure of this application, and the maximum pressure to which this application may be subjected in the event of a single point failure in the immediately preceding control point.
- 5.2, Sufficient material shall be available to permit the preparation and testing of at least 20 specimen samples prepared as follows:
- 5.2.1 Sheet materials shall be tested as 0.188 ± 0.005 inch diameter discs (pneumatic tests) and 0.250 ± 0.020 inch diameter discs (mechanical impact). Test specimens shall be fabricated to 0.075 ± 0.005 inch (thick) discs.
- 5.2.2 Elastomeric "O" ring materials shall be tested as 0.188 ± 0.005 inch diameter discs (pneumatic

impact and 0.250 ± 0.020 inch diameter discs (mechanical impact). Test specimens shall be fabricated to 0.075 ± 0.005 inch (thick) discs, obtained by uniformly slicing the disc samples from "O" ring materials having a cross section diameter of at least 0.250 ± 0.020 inch.

5.2.3 Materials such as greases and fluids whose thickness are not dictated by conditions of use shall be tested as 0.005 ± 0.002 inch layers in test cups. This is applicable to both pneumatic tests and mechanical impact tests.

5.2.4 Coating materials such as paints shall be applied to stainless steel planchets as films, according to spacecraft configuration requirements. These films should be tested at 0.005 ± 0.002 inch thickness. After samples have dried or cured, place in the regular specimen cup for test.

5.2.5 Solid materials which cannot be provided in sheet form shall be tested in the most feasible manner available to the test agency. Such tests shall be designed as special tests, and the test parameters shall be identified in the test report.

5.3 Sampling Cleanliness

Spacecraft material specimens shall be cleaned in accordance with Enclosure A, Revision 1.

6.0 PRETEST PROCEDURE

6.1 Verify that all test equipment has been thoroughly cleaned according to Enclosure A, Revision 1.

6.2 Verify that all test equipment is in current calibration.

6.3 Verify the material identification by one of the items below:

6.3.1 Manufacturer's Certification

6.3.2 NASA Certification

6.3.3 Contractor Certification

NOTE: In the event positive identification cannot be made, so indicate on the test report.

6.4 Verify that the cleaned metallic components and GOX transfer lines are assembled, installed and proof tested, and meet cleanliness requirements of Enclosure A, Revision 1.

7.0 TEST PROCEDURE

7.1 Part A - GOX Pneumatic Impact

7.1.1 Place the sample in position within the sample chamber cavity (Figure 2) and assembly accordingly.

7.1.2 Samples shall be tested in 95⁺⁵₋₀ percent oxygen at a pressure equal to the maximum application pressure

multiplied by a factor 1.33 and rounded to the next higher 500 psia pressure increment. (200 psia increment for application-pressure/safety-factor product of less than 1000 psia).

7.1.3 Close the quick acting valve and the bleed valve prior to pressurizing the system.

7.1.4 Pass gaseous oxygen from the high pressure oxygen source (Figure 1) to the ballast bottle and pressurize to the applicable test pressure specified in 7.1.2. Allow for line pressure drops.

7.1.5 Stabilize the test chamber (Figure 1) temperature to ambient conditions.

7.1.6 The material being tested is subjected to cyclic high pressure oxygen. This is accomplished by opening the quick-acting valve (V_1), pressurizing the test chamber, equalizing the ballast pressure (P_1), and opening the bleed valve (V_2). The test chamber is pressurized within 95% of the total pressure rise in 20 ± 7 milliseconds and cycled for five complete cycles, the duration of each cycle shall be 12 seconds.

7.1.7 Disassemble the test chamber.

7.1.8 Remove the material sample and examine for evidence of pneumatic GOX incompatibility (Section 4.1 and 4.2).

7.1.9 Record all observations.

7.1.10 Repeat the above sequence three additional times using a new sample of the test material each time, assuring the cleanliness requirements of Enclosure A, Revision 1, are maintained.

7.2 Part B - GOX Mechanical Impact

7.2.1 Candidate materials shall be subjected to GOX pneumatic test conditions (Section 7.1) and verified acceptable in accordance with Sections 4.1 and 4.2. The samples are further required to be subjected to GOX mechanical impact energy of 50 ± 3 foot-pounds/inch². The impact loading value shall be determined by the striker pin's impact surface which is in direct contact with the material sample. A sketch of the standard mechanical impact chamber is shown in Figure 3. The test pressure shall equal the maximum application pressure multiplied by 1.5 and rounded to the next higher 500 psia increment. (200 psia increment for application-pressure/safety-factor product of less than 1000 psia.)

- 7.2.2 Place the sample in position within the sample retainer cavity. Verify that the sample is contained in a specimen holder and cup assembly which will allow for the transfer of impact energy to the subject specimen in a repetitious manner.
- 7.2.3 Oxygen Generation - Pass gaseous oxygen from the high pressure oxygen source and pressurize the test chamber to the applicable test pressure.
- 7.2.4 Set the plummet, pestle, striker or suitable impact device in position. The plummet's weight shall be standardized at 7.50 pounds and dropped from a height of 4.0 inches.
- 7.2.5 Raise the chamber pressure to the desired level.
- 7.2.6 Maintain the pressures in the test chamber at $\begin{smallmatrix} +5 \\ -0 \end{smallmatrix}$ percent of the pressure selected.
- 7.2.7 Maintain the temperature at $70 \pm 10^{\circ}\text{F}$.
- 7.2.8 Activate the striker device.
- 7.2.9 Record the temperature and pressures in the chamber before, during, and after the test.
- 7.2.10 At the conclusion of the test, release the residual GOX pressure in the assembly.
- 7.2.11 Disassemble the apparatus.

- 7.2.12 Examine the sample specimen and cup specimen holder for visible signs of reaction.
- 7.2.13 Record all observations; photographs of a visual change in the sample specimen, detected and defined by Section 4.0, shall be at the discretion of the Test Engineer.
- 7.2.14 Repeat the above procedure for a total of four drops, each time employing a new sample, assuring cleanliness requirements are maintained.

8.0 REPORTING

- 8.1 Name of material
- 8.2 Vendor and vendor designation
- 8.3 Test results
 - 8.3.1 Pneumatic Impact
 - 8.3.1.1 Initial ballast bottle pressure
 - 8.3.1.2 Temperature change in the vessel
 - 8.3.1.3 Condition of sample after test
 - 8.3.1.4 Number of test cycles
 - 8.3.1.5 Number of failures versus number of samples tested
 - 8.3.1.6 Date of test
 - 8.3.1.7 Name and number of test procedure

8.3.1.8 Identity of testing organization or agency

8.3.1.9 Name and signature of test conductor

8.3.1.10 Pertinent comments and observations of
test agency

8.3.2 Mechanical Impact

8.3.2.1 Initial pressure of test chamber

8.3.2.2 Temperature change in the vessel

8.3.2.3 Condition of the sample after test

8.3.2.4 Number of mechanical impacts

8.3.2.5 Number of failures versus mechanical
impacts

8.3.2.6 Date of tests

8.3.2.7 Name and number of test procedure

8.3.2.8 Identity of testing organization or agency

8.3.2.9 Name and signature of test conductor

8.3.2.10 Pertinent comments and observations of
test agency

WSTF - PNEUMATIC IMPACT TEST SYSTEM

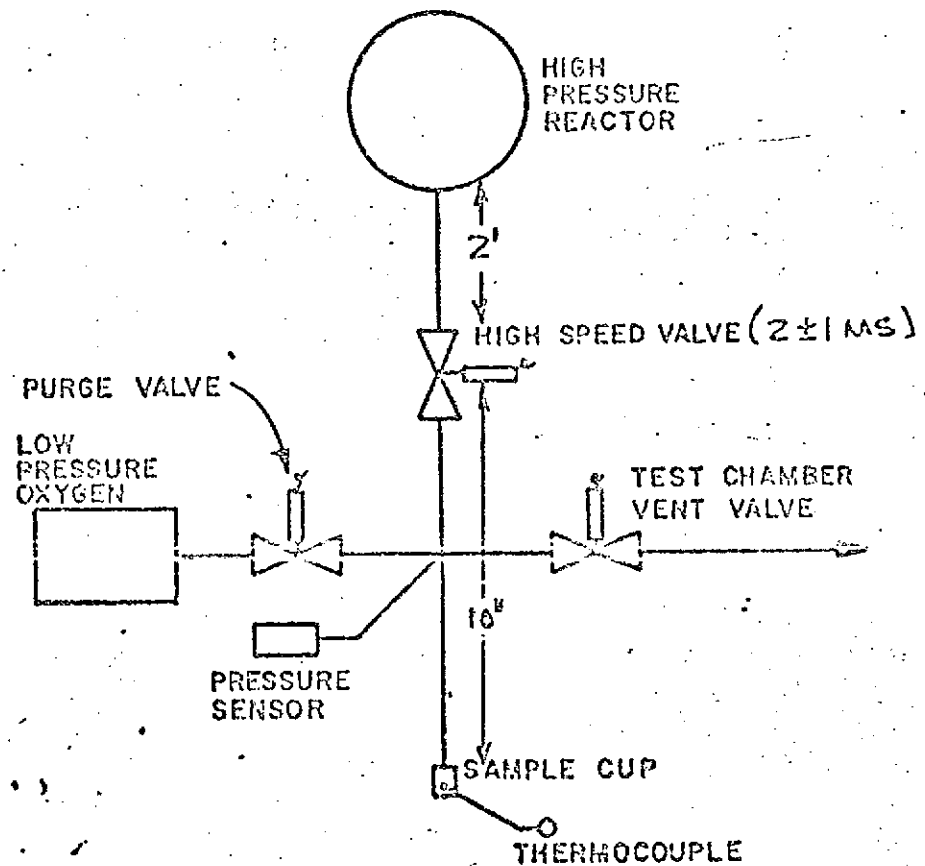


FIGURE 1

WSTF - PNEUMATIC IMPACT TEST SYSTEM

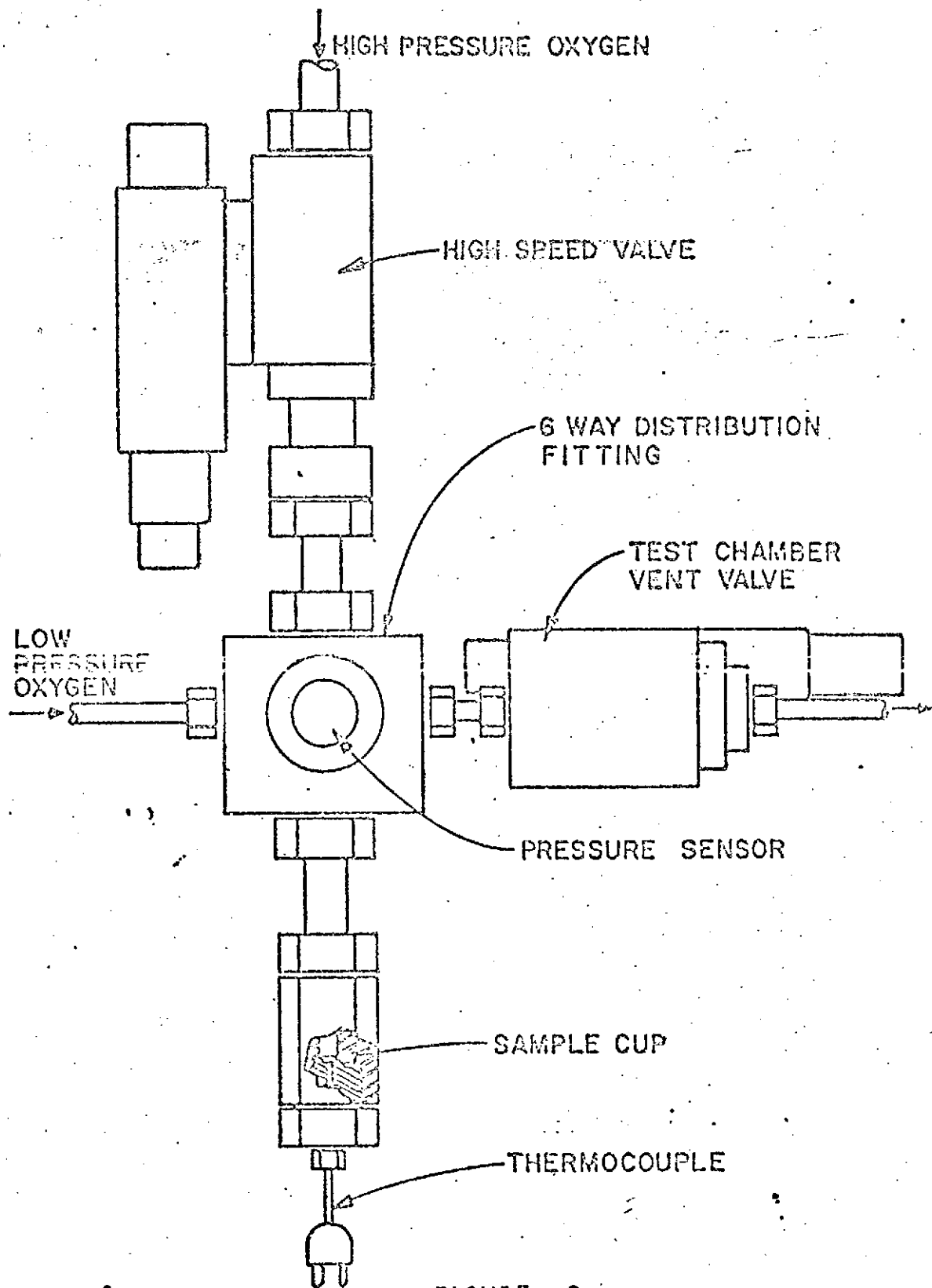


FIGURE 2

WSTF - MECHANICAL IMPACT TEST CHAMBER INSTALLED ON BASIC ABMA TESTER

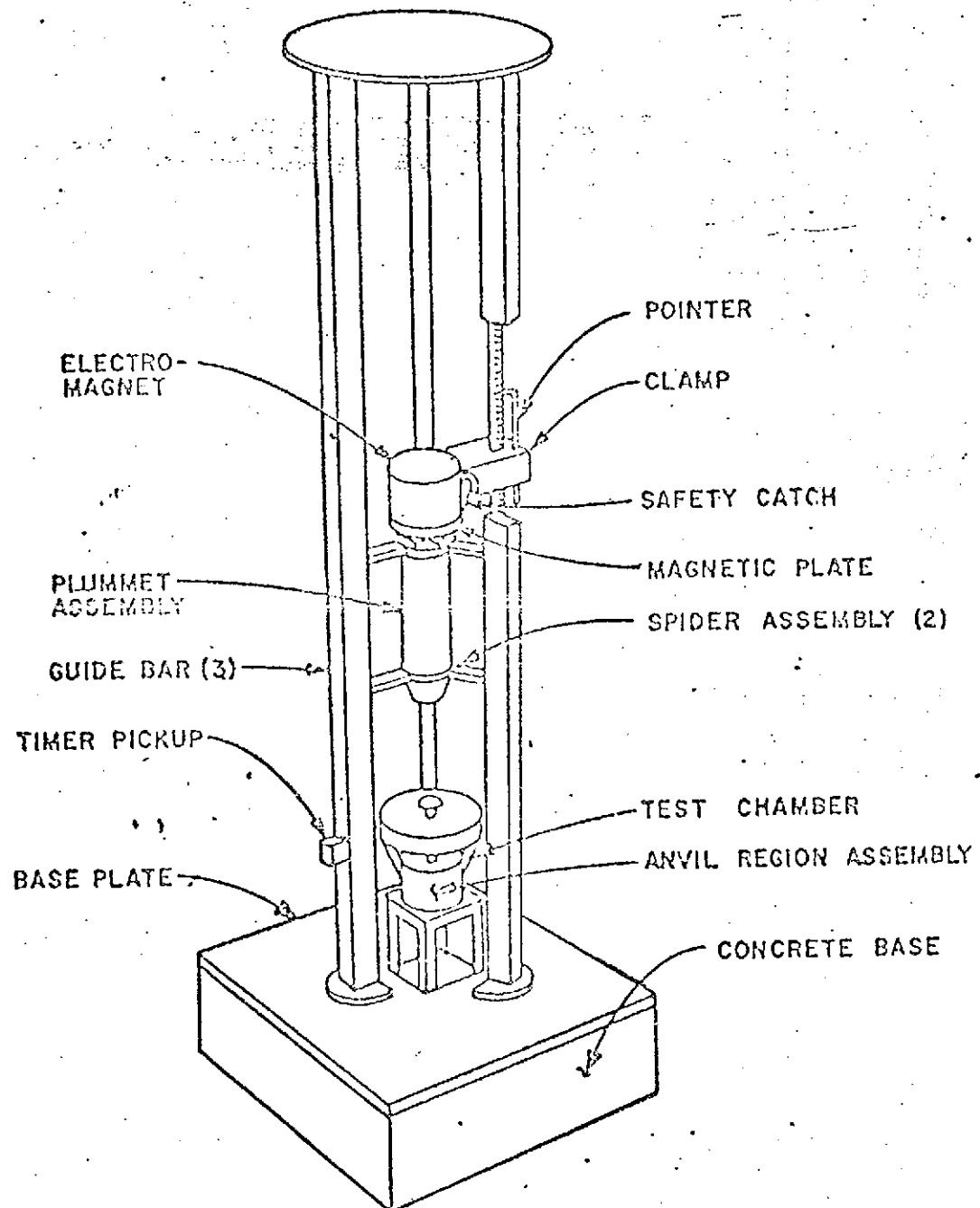


FIGURE 3

WSTF - MECHANICAL IMPACT TEST CHAMBER

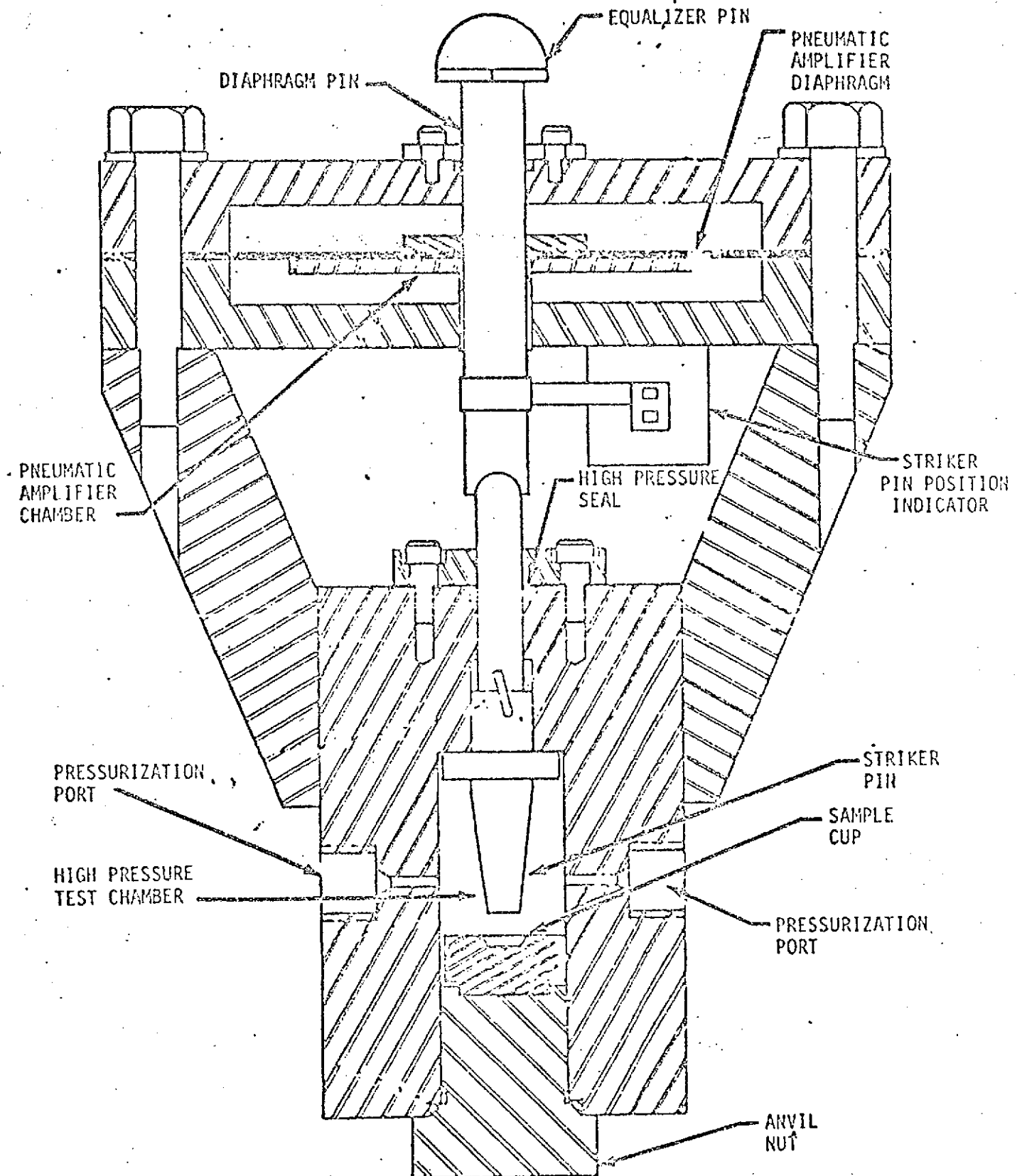


FIGURE 4

ENCLOSURE A
PRECISION CLEANING GUIDELINES
for
GOX IMPACT TEST SPECIMENS AND TEST APPARATUS

1.0 PURPOSE

These requirements are written to assure that cleanliness conditions are maintained and testing of materials is undertaken under uniformly clean conditions. These cleaning guidelines shall assure that nonmetallic materials specimens are subjected to uniform cleaning methods which are repeatable. The method is intended to remove hydrocarbons which contaminate the surface during manufacturing, handling, processing, and shipping.

2.0 SCOPE

These guidelines describe methods of cleaning material test specimens. The constraints implied by cleaning and the techniques of cleaning are only generally covered. Particulate contamination shall be controlled by assuring freshly prepared cleaning solutions. These guidelines are not an operating procedure or job instruction which details every specific step required to perform a cleaning operation. These operating procedures/job instructions are the responsibility of the operating element and are not within the scope of this document.

3.0 VISUAL EXAMINATION

3.1 All material specimens and test apparatus shall be visually inspected to detect signs of contamination. Methods employed within the sample preparation area shall be those which can be utilized during inspection and verification to determine the amount of precleaning required. Any contamination

shall be cause of recleaning (see Section 4.0). Observations must be made with the unaided eye and light of sufficient intensity to illuminate the area being inspected during the initial material cleanliness inspection.

- 3.2 All material specimens shall be free of cuts, abrasions, and other flaws as determined by close visual inspection without magnification.

4.0 CLEANING

4.1 MATERIALS

- 4.1.1 Before any GOX impact test, the material specimens shall be precleaned by brushing with a nylon brush and by flowing an inert gas over them to remove loose surface contamination, followed by reinspection as specified in Section 3.2.
- 4.1.2 Only lubricant and grease test specimens should be tested in their "as used" condition; that is, no special cleaning processes other than those used to prepare the material for application or assembly test.
- 4.1.3 All other test specimens should be subjected to the following general cleaning provisions consisting of the removal of such gross surface contaminants as scale, grease marks, manufacturing residues, excess plasticizers, corrosion and oxidation products, etc., prior to final precision cleaning per this specification. Solvent cleaning shall be limited to water and mild detergent since further solvent action can change the physical and chemical properties of materials by leaching or solvent absorption, thus altering the sensitivity to GOX impact. The cleaning method proposed here is uniformly applied to all materials (see 4.1.2) prior to performing GOX impact tests and correlates with existing contractor cleanliness specifications.
- 4.1.3.1 Rubber gloves, or equivalents, shall be worn during all cleaning operations. Cleaned surfaces shall not be handled with bare hands. Clean (low-lint) white nylon gloves, or equivalent, shall be worn when handling cleaned

Items. During and subsequent to cleaning, care shall be taken not to recontaminate parts. Cleaned parts shall be placed and sealed in at least an equally cleaned Teflon, or equivalent, (see Section 6.0) package.

- 4.1.3.2 Cleaning and inspection processes per this specification are designed not to be detrimental to nonmetallic materials or test apparatus parts. When a procedure herein is not directly applicable to nonmetallic material specimens, those specimens shall not be processed per this specification.

4.1.4 Cleaning Materials

- 4.1.4.1 Rinse Water - Rinse water shall be of the distilled or deionized variety, except that a minimum resistance of 50,000 ohm-cm is acceptable. Water shall be filtered through a 25 micron (absolute) filter or better, prior to use for spraying or flushing.

- 4.1.4.2 Detergent - Detergent shall be added to deionized water in accordance with concentration requirements of Section 4.1.5.4 and then passed through a 25 micron (absolute) filter, or better, prior to use, for flushing/decontamination purposes.

- 4.1.4.3 All material specimens shall be cleaned by using a freshly prepared detergent solution of one of the following types (i.e., Liqui-Det. #2, Turco 4215S, Ivory Liquid Detergent).

4.1.5 Cleaning Methods

Where applicable, WSTF Instruction Manual, No. 3552, Process No. 3, shall be followed. This method establishes cleaning methods of elastomeric parts (rubber, elastomers, o-rings, and other plastic or synthetic nonmetallic materials).

- 4.1.5.1 Precleaning - Where application (Section 4.0), samples and test apparatus shall be precleaned prior to conducting any GOX mechanical or pneumatic tests.

- 4.1.5.2 Samples and test apparatus shall be first inspected for any signs of abrasion, etc., and brushed clean, using a nylon brush.

- 4.1.5.3 The material specimens shall then be decontaminated, using cold tap water. Flush with water until pH of effluent is within 0.5 pH unit of influent, but do not flush less than two minutes.
- 4.1.5.4 Perform detergent cleaning (Section 4.1.4.3) using 1/2 to 1 oz. of detergent/gallon of deionized water. Assist cleaning with nylon brush. Immersion time shall be 5 ± 1 minute at bath temperature of 120 - 150°F. Agitation, not ultrasonic, shall be effected for a period of not less than 30 seconds prior to removal from detergent bath.
- 4.1.5.5 Soak and agitate for not less than two minutes with deionized water (see Section 6.0) (140° maximum) until no evidence of detergent solution is apparent.
- 4.1.5.6 Rinse-spray using deionized water for at least ten thorough applications.
- 4.1.5.7 Place samples in clean Petri dish.
- 4.1.5.8 Dry for 5 minutes with nitrogen (GN_2) filtered through a membrane filter not exceeding a 4.5 micron pore size, and package in a Teflon package.
- 4.1.5.9 Samples have now been uniformly cleaned and are ready for GOX mechanical/pneumatic testing.

4.2 TEST APPARATUS

- 4.2.1 Prior to performing any GOX impact test, the test chamber and components, where necessary as determined by Section 3.0, shall be degreased in a solution of detergent and demineralized water or Freon, depending upon the contaminants. Rinsing or flushing shall be thorough, followed by adequate drying, such as passage of dry nitrogen, air, or inert gas over the sample.
 - 4.2.1.1 Application of any cleaning solution must be restricted to usages where problems subsequent to cleaning will not occur as a result of the application; e.g., corrosion from entrapped cleaning fluids that might alter a material's GOX impact characteristics, etc.

4.2.1.2 All steps in any procedure must progress in an uninterrupted series of operations through the final rinse and drying operation. Precautions must be taken to assure that cleanliness is maintained until testing commences.

4.2.2. Cleaning Materials

4.2.2.1 Rinse Water - See Section 4.1.4.1.

4.2.2.2. Detergent - See Section 4.1.4.2.

4.2.2.3 Cleaning Solvents - Cleaning Solvents shall be Freon TF (only for cleaning test fixture and apparatus) and shall be filtered through a 4.5 micron (absolute) filter, or better, prior to use. Nonmetallic materials shall be suitably cleaned via water/mild detergent.

Nonvolatile Residue - The NVR content of the Freon solvent shall not exceed 1.0 mg per 100 ml.

5.0 CLEANLINESS REQUIREMENTS

In the absence of specific cleaning requirements, a particular specimen shall meet the visual cleaning inspection level as set forth in Section 3.0 of this cleaning guideline.

6.0 DOCUMENTATION

6.1 Nitrogen (MSFC-SPEC-234A).

6.2 Freon TF (final passage through 0.45 micron absolute filter, NVR maximum of 1.0 mg/100 ml).

6.3 Teflon Packages - Cleaned to MSC-C-23, Level 1, prior to use.

6.4 Deionized water (MSC-SPEC-C-20A).